AN ABSTRACT OF THE THESIS OF

Charles J. Ferrari for the degree of Master of Science in Forest Products presented on October 13, 2000. Title: Life Cycle Assessment: Environmental Modeling of Plywood and Laminated Veneer Lumber Manufacturing.

Signature redacted for privacy.

Abstract Approved: ______________________________
James B. Wilson

Amidst the oil crisis in 1976, a Committee on Renewable Resources for Industrial Materials (CORRIM) was appointed to perform a study on renewable resources–wood products–in the United States. The CORRIM study focused on material flow and energy consumption; emissions were not studied. Up until now, this was the only massive environmental type study done on the forest products industry. CORRIM II (Consortium for Research on Renewable Industrial Materials) has been recently formed to perform a Life Cycle Assessment (LCA) of the forest products industry. As part of this overall study, models are developed for determining the environmental impact of manufacturing plywood and laminated veneer lumber (LVL) gate-to-gate. The models enable comparison for various process management scenarios, accounting for all input and output values and can be used by decision makers. Values considered include inputs such as logs, resin, water, electricity, fuels, and ancillary materials, and outputs such as plywood, LVL, by-products, and air, water, and land emissions. SimaPro, an LCA software program, is used to develop the models. The manufacturing processes are modeled in terms of six machine centers: debarking and bucking, block conditioning, peeling and clipping, drying, hot pressing, and trimming and sawing; considering all inputs and outputs for each. Two production regions of the U.S. are analyzed: the

Pacific Northwest and the southern region. Using emissions data from the National Council for Air and Steam Improvement (NCASI) and ATHENA™, and energy data from industrial sources and the Energy Information Administration, specific to each region, base case scenarios for the models were performed. Sensitivity analyses were performed on the heating fuel source and the pollution control device. First the quantitative results were analyzed, followed by an environmental impact assessment. The environmental impact assessment was performed via the Eco-indicator99 methodology developed by PRe Consultants, which takes into account ecosystem quality, human health, and resources. The hot pressing, veneer drying, and log conditioning had the largest amount of emissions and the greatest environmental impact because of the heat required at each machine center. Energy consumption during the plywood and LVL manufacturing processes has the greatest impact on the environment. Using 100% hog fuel as a heating fuel source increased CO_2, CO and solid waste emissions, but decreased SO_X, NO_X, methane, Biological Oxygen Demand (BOD), suspended and dissolved solids, compared to 100% natural gas. Using 100% natural gas as the heating fuel source had double the environmental impact compared to 100% hog fuel. Wet Electrostatic Precipitators (WESPs), Regenerative Thermal Oxidizers (RTOs), and Regenerative Catalytic Oxidizers (RCOs) proved to reduce certain air emissions at the dryer stack, but increased the environmental impact because of the energy and electricity required to operate the pollution control devices. These models should serve as a useful tool for analyzing the plywood and LVL manufacturing processes.

Life Cycle Assessment: Environmental Modeling of Plywood and Laminated Veneer Lumber Manufacturing

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LIFE CYCLE ASSESSMENT: ENVIRONMENTAL MODELING OF PLYWOOD AND LAMINATED VENEER LUMBER MANUFACTURING

INTRODUCTION

BACKGROUND

In 1969, the first Life Cycle Assessment (LCA) was conducted comparing beverage containers (Hunt, 1992). "LCA is a technique for assessing the environmental aspects and potential impacts associated with a product" (ISO 14040, 1997). Concerns of resource depletion and the decreasing quality of the environment were the driving factors in this early study (LeVan, 1995). Although these concerns were growing, they only troubled a minority. Not until the 1970's did the United States as a whole recognize the importance of natural resources. With the first oil shortage in 1973-4, followed by a gasoline shortage in 1977, President Carter recognized an energy crisis and deemed it as "the moral equivalent of war" (Oak Ridge National Laboratories, 1999).

Prior to this declaration, many groups began research on commercial and residential resource consumption. More specifically, the Science and Technology Policy Office, supported by the Science Advisor of the President, requested a study on renewable resources to address the nation's future material needs (CORRIM, 1976). In 1974, this task was assigned to an appointed committee: the Committee on Renewable Resources for Industrial Materials (CORRIM). In the broadest of terms, CORRIM was tasked to analyze the United States' renewable resources, their optimal usage, and the use of technology and science to overcome the barriers for resource use and production (CORRIM, 1976). The majority of building materials at the time were wood based.

Essentially, this was a massive forest products assessment. Since the first LCA comparing beverage containers, other product comparisons have been made on products such as vacuum bags and newspapers (LeVan, 1995). Amidst all these studies, some of which were performed on the same products, there was little consistency in the results.

Currently, there is a drive to standardize the LCA Process. The majority of recent published studies use the following format as a guideline. This format is the basis of discussion for standardization.

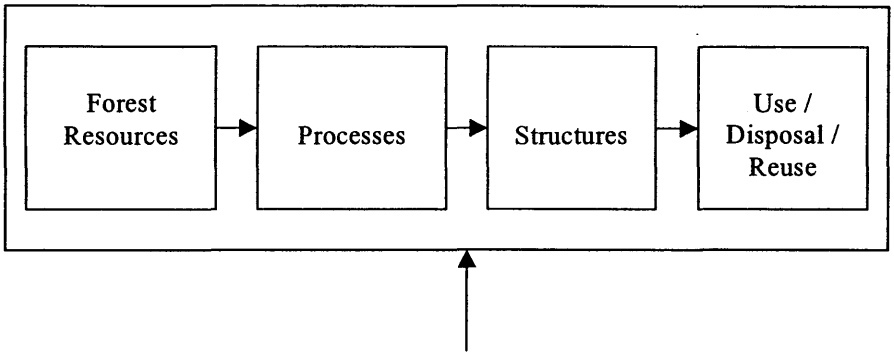
- Scope and Goal - define and state the purpose of the LCA,
- Life Cycle Inventory Analysis (LCI) - tracks all inputs (i.e. raw materials and energy) and outputs (i.e. products, emissions) of a chosen system from the extraction of raw materials, manufacturing of the product, use of the product, and disposal or recycling of the product,
- Impact Assessment - estimates the environmental impact of the process, and
- Improvement Assessment (life cycle interpretation) - targets the greatest impact for change (Higham and Todd, 1998 for entire paragraph).

The term environment and all derivations of, will be defined as the surrounding area the specimen or subject of the discussion. The general purpose of any LCA is analyzing a process, pinpointing areas for improvement, and determining processes that minimize their impact on the environment. These impacts will be determined according to SimaPro software and the Eco-Indicator99 methodology that it uses. Numerous amounts of these "cradle-to-grave" studies are performed on a variety of materials, renewable and non-renewable. Each industry group has a different environmental claim to support its use (i.e. trees are renewable, steel is the most recycled, and concrete is abundant and a local resource) (Meil, 1996).

Non-renewable material industries, especially steel, are the leaders for data collection in regard to LCA. Steel has taken the initiative to gather information and places great emphasis on completing these studies. The International Iron and Steel Institute (IISI) has created the largest LCI database of any material (World Steel, 1998). An LCI is defined as the "...compilation and quantification of inputs and outputs, for a given product system...(ISO 14040, 1998)." Using the database, studies are being performed to increase steel's life cycle knowledge, create benchmark standards, and promote communication within the steel industry (World Steel, 1998). The steel industry markets itself as the most recycled material. It supports this claim with facts such as, 12.5 millions tons of steel was recycled from automobiles in 1996 (American Iron and Steel Institute, 1999).

In the past decade, universities have followed the lead of the steel industry in their study of forest products. CORRIM II, the Consortium for Research on Renewable Industrial Materials, was created to update the renewable resource assessment of the 1976 CORRIM report. This committee's research plan consists of twenty-two research modules with the first phase consisting of five modules: forest resources, processes, structures, use/disposal/reuse, and data management. This first phase evaluates structural building materials (Figure 1).

Figure 1: LCA process for the structural wood products phase.



SYSTEM BOUNDARIES

Forintek Canada Corporation created a prototype model, ATHENA™, to address Life Cycle Assessment. This model allows the building community to evaluate the environmental impact of various structural building materials, such as wood, steel, and concrete (Meil and Trusty, 1995). Other groups, such as the National Council for Air and Stream Improvement (NCASI) are developing an air emissions database for the manufacturing of structural forest products such as plywood. Data from this database is considered primary if used by NCASI and secondary if used by anyone else.

The development by agencies of these types of databases, which are the most time and money consuming parts of LCA, assisting manufacturers who perform the tedious, but critical LCA studies. These LCA studies foster product development and improvement, strategic planning, public policy making and marketing with specific objectives focused around improvement, comparison, and communication (Richter, 1998).

Since the LCA process is subjective and methodologies differ from one study to the next, there is a need for standardization. Three major organizations are attempting to develop the standards for performing the LCA: the International Organization for Standardization (ISO), the Society of Environmental Toxicology and Chemistry (SETAC) and the American Standards of Testing and Materials (ASTM). As the standards come closer to completion, debate still exists on whether the impact assessment steps have any scientific basis (LeVan, 1996).

CHALLENGE

Over the past two decades, environmental awareness has increased substantially worldwide. The environment and how we treat it is at the forefront of society and decision-makers. Scientists have identified numerous environmental and health concerns related to resource extraction, energy use, and air, land, and water emissions, and disposal of products. Some concerns expressed included human health, ecosystem quality, and resource usage. Society calls for resolution or minimization of these concerns. LCA is the tool used to address these growing concerns.

LCA is a "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040, 1997)." Although the definition sounds simple and is accepted internationally, the LCA process is not. Over the past thirty years many LCAs have been preformed. After multiple LCAs on the same processes, the only consistency is the difference in results. Numerous problems are attributed to the lack of consistency in results: outdated data, lack of data, omission of certain phases in the LCA, databases not available for peer review, and subjective evaluation (Higham, 1998; LeVan, 1995). The source of these limitations is international disagreement on what should be included and studies done at different levels of specificity (Meil and Trusty, 1995).

A major problem pertaining to LCA studies is the impact assessment phase. During the impact assessment there is an attempt to quantify qualitative data. Some information is difficult to quantify, such as environmental impacts. With qualitative data, the ideal scenario would be an objective evaluation of these results. A variety of factors influence one's perception of what is important, such as geography, economics, and personal interests.

As greater emphasis is placed on the environment, LCA is developing into a powerful tool for the marketing world. More specifically, wood and non-wood industries are attempting to position themselves as the "green choice" with marketing campaigns (Meil, 1996). Using their past LCA reports and findings for marketing purposes raises some concerns. These concerns express the use of LCA as a marketing tool without a standardized methodology (Feldmen, 1996). The over abundance of varying LCA results for similar products are giving consumers mixed feelings about LCAs in general. The International Organization of Standards (ISO) has completed the ISO 14000 to address the standardization issue.

This paper addresses one portion, a gate-to-gate study, of an LCA study covering two structural wood products: plywood and laminated veneer lumber. More specifically, accounting is done for all inputs and outputs from the log deck through to the product ready for shipment. The study products are plywood and laminated veneer lumber (LVL) manufacturing in the Pacific Northwest (Oregon and Washington) and four of thirteen states in the Southern Region (Alabama, Louisiana, Georgia, Mississippi) of the United States. In an attempt to make the study as transparent as possible, currently published ISO 14000 standards and CORRIM methodologies are followed (ISO 14000, 1997 and CORRIM 2000).

OBJECTIVES

The general objectives of this research are to assist policy makers, material buyers and mangers on their policy and material choice decisions with respect to forest products. The LCA tool should help these decision makers account for the environmental concerns raised by society. These concerns will be addressed later. Furthermore, this research is a step toward including environmental impact as a decision factor for material purchasers, along with the traditional pricing and availability factors.

The specific objectives are as follows:

1. Create LCI working models of the LVL and plywood manufacturing processes for the Pacific Northwest and southern regions of the United States.
2. Provide insight to the manufacturing process by segmenting plywood and LVL manufacturing processes into machine centers.
3. Determine which machine centers contribute the most to environmental problems, their causes, and perform a sensitivity analysis on certain parameters according the Eco-Indicator99 methodology.

4. Provide a useful gate-to-gate study to assist CORRIM II's processing module for their LCA on forest products.

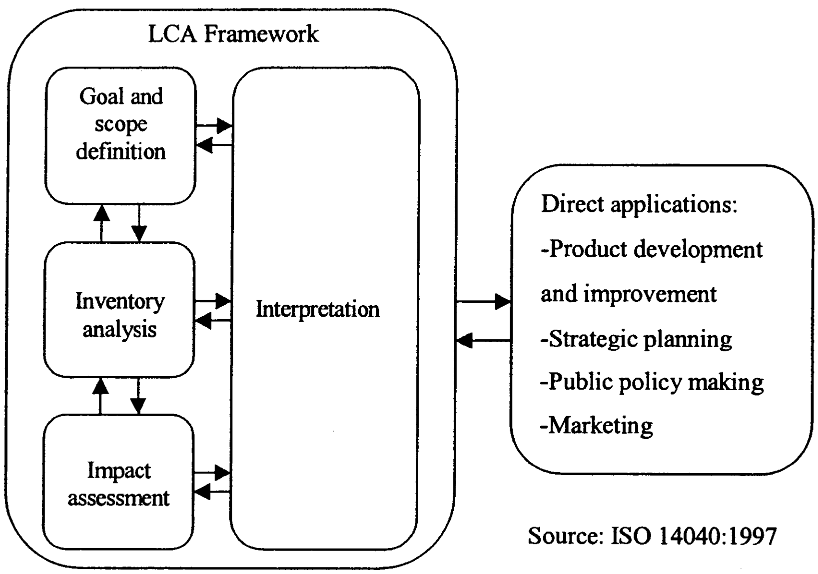
Essentially, these models examine the trade-offs between different raw materials, fuels, and equipment. Also, conversion efficiencies between products and inputs, along with unitization of undesirable outputs, if possible.

PLYWOOD AND LVL MODEL DESCRIPTIONS

LCA DESCRIPTION

Although this study is not a complete Life Cycle Assessment, understanding LCA assists in the comprehension of the following gate-to-gate study. According to the ISO 14040 standards, LCA consists of four phases: goal and scope definition, inventory analysis, impact assessment and interpretation (Figure 2). Note that these standards are still developing and may change.

Figure 2. Phase of Life Cycle Assessment as defined by ISO 14040:1997).

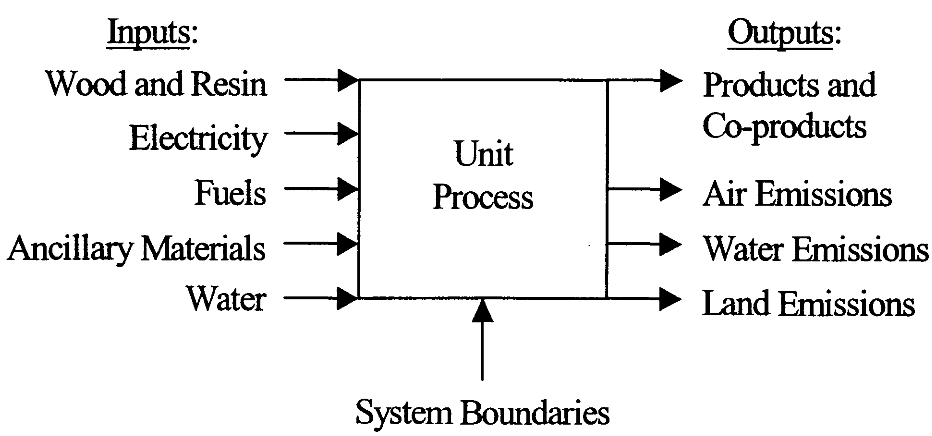


Source: ISO 14040:1997

The initial phase–goal and scope definition–is critical to the completion of the other three phases. The goal clearly states the intended use, reason and audience of the study. The scope of the study describes the study parameters. Areas requiring consideration include: the functions the system studied, the system boundaries, allocation procedures, methodology for the impact assessment and other interpretation, data requirements, assumptions, limitations and/or any review processes. This list serves as a guideline for defining the scope and may be followed liberally. Portions of the previous list are described in greater detail as they pertain to the LVL and plywood sheathing study.

The most time consuming portion of LCA is the LCI phase. LCI consists of gathering and calculating data that quantifies all relevant inputs and outputs of the studied process. Figure 3 depicts a generic input/output flow for a composite wood product process. During LCI, new insight on limitations and opportunities may occur, allowing modification of the goal and scope. The results of this phase are of the greatest

Figure 3: Unit process inputs and outputs.



importance to the plywood and LVL study. Once the LCI is complete, the impact assessment phase commences.

During the impact assessment phase, the LCI results are used as inputs. Using these inventory numbers, the significance of the environmental impact is evaluated. Generally, this phase is broken down into three elements: classification, characterization and weighting (normalization) (ISO 14040,1997). Classification involves grouping the system outputs according to environmental and human effects (i.e. climate change, resource depletion, carcinogens). Characterization includes evaluating the data within each grouping. Weighting is the attempt to place all groups at an even level for evaluation. Once again, this may give new insight to the limitations and opportunities of the selected study and allow for goals and scope altering.

As stated in ISO 14040:1997 "*The methodological and scientific framework for impact assessment is still being developed. Models for impact categories are in different stages of development. There are no generally accepted methodologies for consistently and accurately associating inventory data with specific potential environmental impacts.*" Furthermore, impact assessment is extremely arbitrary and should be made as transparent as possible.

Interpretation is already integrated throughout the first three phases. The final step of interpretation involves evaluating the data from the LCI and the impact assessment conclusions. From here, conclusions, observations and recommendations are made. It is suggested that the study undergo a peer review by ISO.

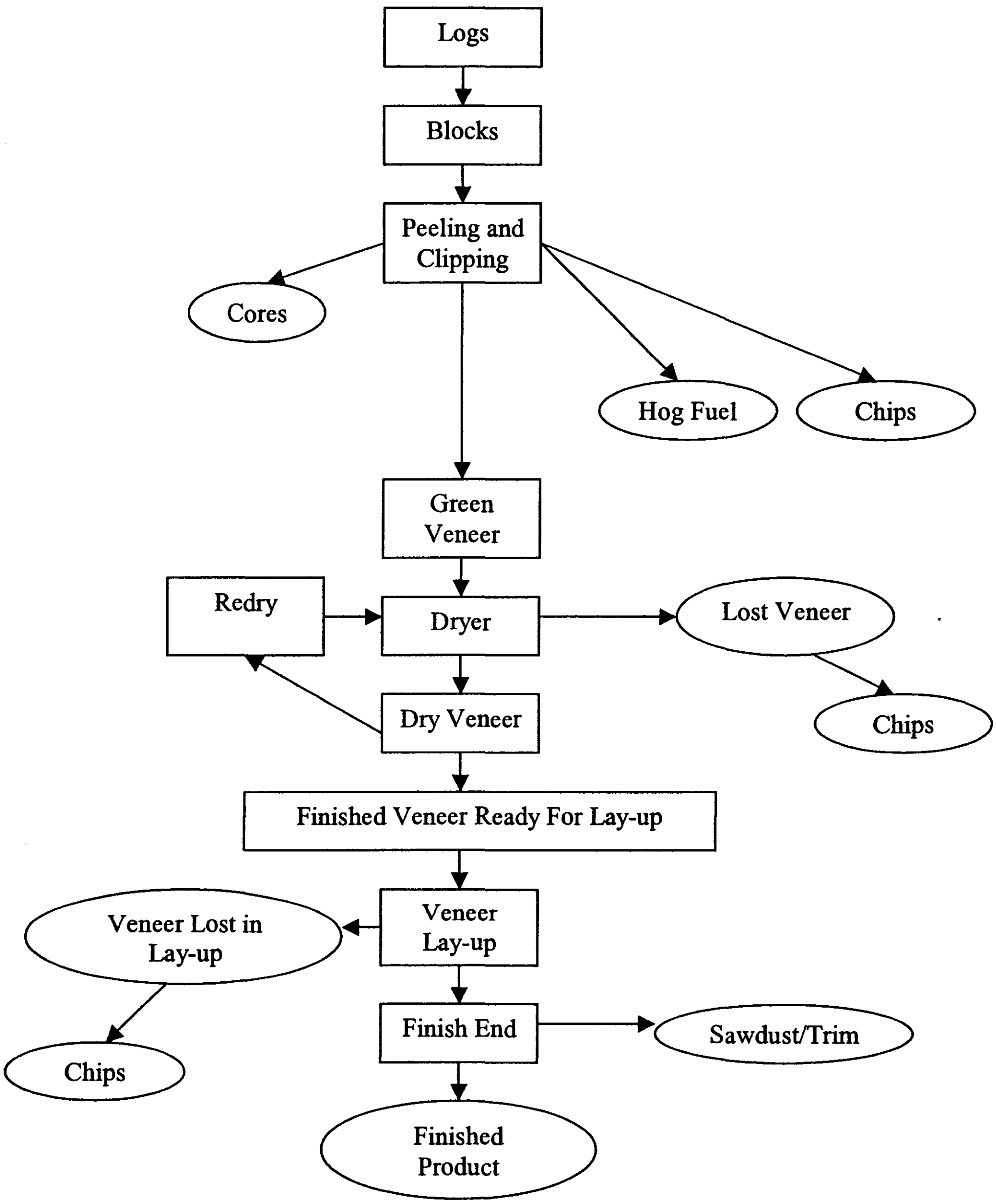
FUNCTION AND FUNCTIONAL UNIT

When forming the scope of the project, one primary issue is addressing the function of the study. By defining the function of the study, the product's specifications and/or performance characteristics are described qualitatively. Using the identified functions, a functional unit is defined. A functional unit is a "measure of performance that the product or service system delivers (Feldman and Tibor, 1996)." The purpose of a functional unit is to provide a reference for standardizing outputs and inputs. This normalization is important for compatibility of studied products and services (ISO 14040, 1997). Once the functional unit is defined, the reference flow is quantified. The reference flow refers to the amount of outputs needed to fulfill the function. The function and functional units for plywood sheathing and LVL will now be defined.

In general, plywood, is used for residential, non-residential and industrial applications. There are a variety of uses for softwood plywood which include: subflooring, wall and roof sheathing, structural insulated panels, marine applications, siding, and concrete forming. For this gate-to-gate study, the manufacturing of softwood plywood sheathing is the focus (Figure 4). The primary function of this process is producing sheets of softwood plywood. The functional unit is defined in terms of thousand square meters on a 9-mm basis (Msm 9-mm basis).

LVL, similar to plywood, is used for residential, non-residential, and industrial applications. The uses of LVL include flange material for composite I-beams, scaffolding planking, headers and beams, and hip and valley rafters. The process described in the plywood section is also used for LVL manufacturing (Figure 4). In many cases, the LVL process takes place at many locations. For example, the veneer is peeled at one location,

Figure 4: Plywood and LVL manufacturing process.



dried at another location, and then shipped to another facility where the rest of the process occurs. For this study the overall process is considered. The primary function of this process is to produce billets of LVL. The functional volumetric unit is defined in terms of cubic meters (m^3).

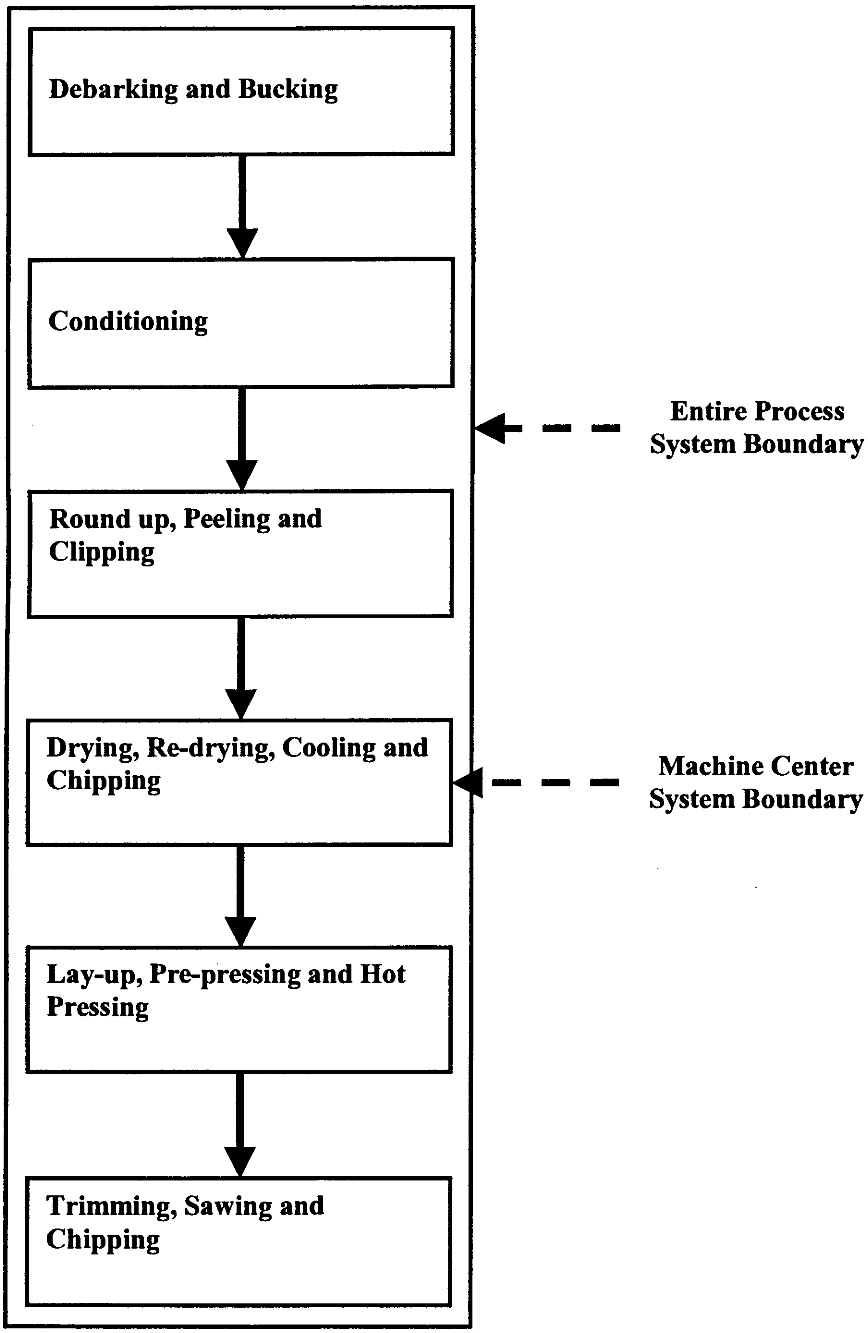
Using the Msm 9-mm basis and m^3 measurements, the CORRIM study can be conducted. These quantities can help assess the inventory of materials used to build a standard house, 204 m^2, in two regions in the United States. The energy used to maintain these houses will also be assessed.

SYSTEM BOUNDARIES

A system boundary is the defined barrier between the process analyzed and the surrounding environment. For this gate-to-gate study, the plywood and LVL system boundaries need definition. All inputs and outputs included between the log deck and the final product and co-products ready for shipping are considered. Transportation is not included, unless specified. The plywood and LVL manufacturing processes are broken down into six machine centers. These machine centers are titled as follows: debarking/bucking, conditioning, peeling/clipping, drying, pressing and trimming/sawing (Figure 5). The processing steps included in each machine center are described below.

The first machine center examined was debarking/bucking. During this sub-process all bark is removed from the log. The log is then transported by conveyor to a cut-off saw where the logs are bucked into desired lengths, called blocks.

Figure 5: Machine centers for plywood and LVL manufacturing.



Conditioning is the second machine center grouping. This sub-process includes conditioning (heating) the blocks in a steam or hot water vat.

Following the conditioning machine center is peeling/clipping. The conditioned blocks are placed in the lathe. "Rounding-up" the blocks, removing all irregularities and creating a uniform cylinder, is the first phase performed. After this, the blocks are peeled into ribbons of veneer, which run onto a series of conveyors. Once the peeling is complete, the core drops down to a conveyor. The peeler core and round-up material are transported and separated by conveyors to a storage area. These by-products are ready for reuse. The ribbons of veneer run to the clipper, where defects are clipped out, the veneer is clipped to size, and veneer is stacked automatically. The clippings are transferred via a conveyor to storage with the roundup scraps and peeler cores.

Drying the veneer is the next sub-process considered. The drying machine center includes initial veneer drying, re-drying, and veneer cooling. Some of the veneer out of the dryer is rejected and scraped. This veneer is chipped into dry chips and stored in a cyclone, which is ready for reuse or sale. This chipping process is included in the drying machine center.

In an attempt to control various air emissions, many veneer, plywood and LVL mills use various pollution control devices. These devices are used for controlling particulate and Volatile Organic Compounds (VOCs) emissions generated at dryers, hot presses, and boilers. Scrubbers are still used to control particulate emissions but are being phased out of service. The three other major types of emission control devices currently being used or implemented are: Wet Electrostatic Precipitator (WESP), Regenerative Thermal Oxidizer (RTO), and Regenerative Catalytic Oxidizer (RCO).

Dryer temperature, wood species, veneer throughput, and veneer moisture content affect the magnitude of the emissions (Raemhild, 2000). Average drying temperatures for the Pacific Northwest are in the range of 170-190 degrees Celsius (NCASI, 1999). The dryer temperatures for southern manufactures are higher, ranging from 190-205 degrees Celsius (NCASI, 1999). The Pacific Northwest dries Douglas-fir with an average moisture content (oven-dry basis) of 48%, while the south dries Southern Yellow Pine at 100% (FRL-USDA, 1999; AWPA, 1996). All emissions are reported as a rate in terms of emissions per Msm 9-mm basis.

WESP, RTO, and RCO are used to control particulate, other visible emissions, and VOC. Particulates are either solid or condensible. Solid particulates are usually fiber (wood) dust and referred to as particulate matter (PM). PM10 is filterable and has an aerodynamic diameter less than or equal to 10 μm (Corio and Sherwell, 2000). Condensible particulates are fatty and resin acids (Raemhild, 2000). They are defined by the EPA as having an aerodynamic diameter less than or equal to 2.5 μm, or "fine" PM (EPA, 2000). Visible emissions are what is commonly referred to as "Blue Haze," which are primarily condensible particulates. RTO and RCO are the pollution control devices used for controlling VOC emissions. Currently, WESPs are primarily used in the Pacific Northwest while the south utilizes RTOs or RCOs, sometimes combined with WESPs (Raemhild, 2000).

Once the veneer is dried, it provides one of two inputs required for the pressing machine center. The other input required, the adhesive used to bond veneer to make plywood and LVL, is a phenol formaldehyde resin. All processes associated with phenolic resin production are included. This includes all transportation of raw materials to the resin plant, all fuel, electricity, heat and transportation of the resin to the mill. The initial step of the pressing sub-process involves laying-up the veneer with resin. From here, the unit of laid-up veneer is sent to the pre-press by conveyor. After the pre-press, the unit is automatically loaded into a hot-press. During the lay-up process, some veneer with resin is rejected. This material is transported by conveyor to a chipper and stored in a cyclone. This chipping is included in the next process, trimming/sawing.

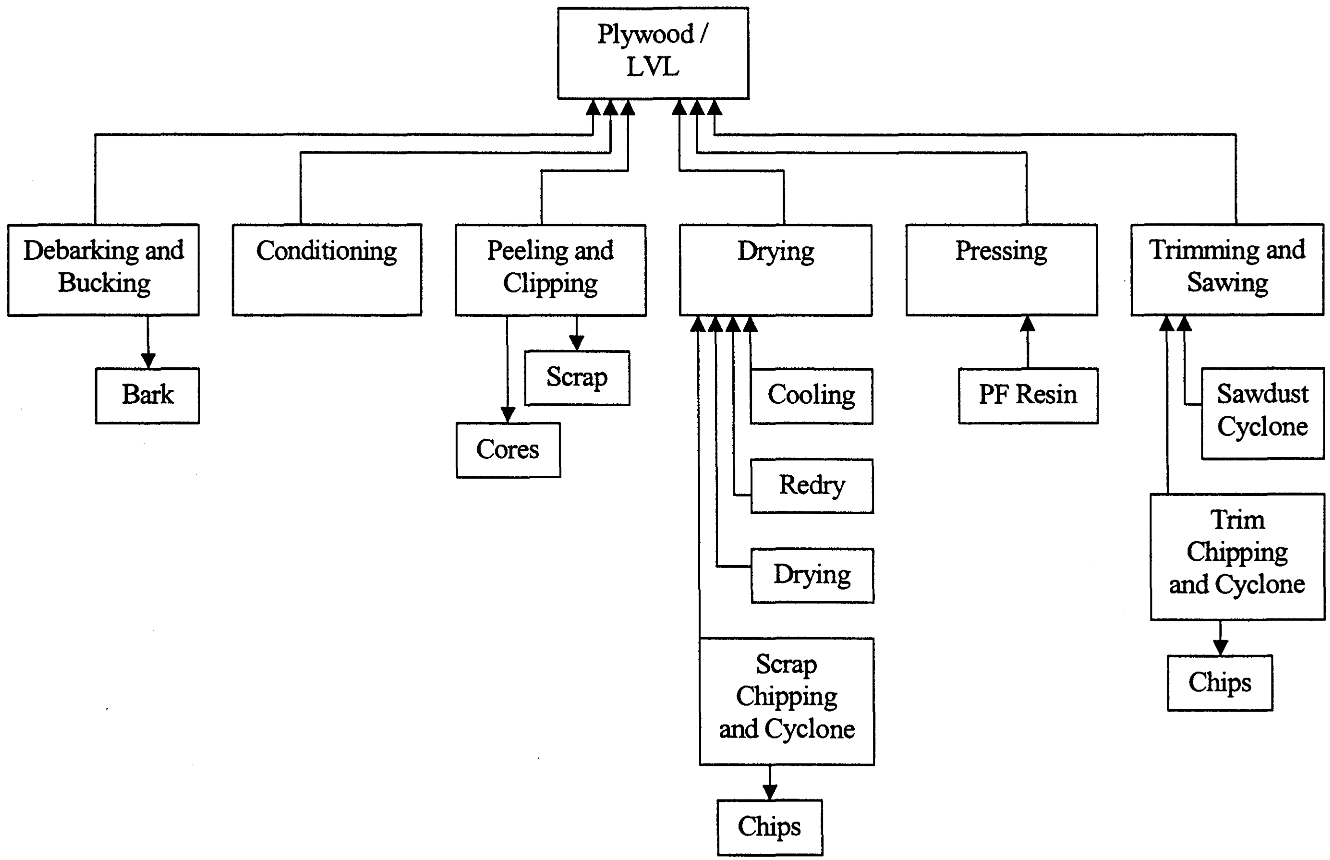
The final process considered is the trimming/sawing machine center. This involves trimming the edges of the panels and billets and sawing them into the correct dimensions. The scraps and sawdust are transported, the scraps are chipped and all material is stored in a cyclone. This transformation, along with the lay-up scraps, are included in the trimming/sawing machine center.

As described in the previous paragraphs, many sub-processes can make-up a machine center, such as the drying machine center. Since the objective is to create a working model of the manufacturing processes, the model was designed accordingly. Figure 6 shows the machine centers in detail. For example, the drying machine center is made up of four processes. These processes are separated for data entry purposes. When new data are collected or generated for a particular process, the model can be updated. This would be difficult if all the processes were lumped together.

ALLOCATION RULES

For machine centers producing by-products that are recycled or serve as an input to other manufacturing process, allocation is required. Allocation is the procedure of assigning energy flows and emissions to the by-product. Allocation is based on physical

Figure 6: Machine center layout in detail.



properties, economic value, or the number of subsequent uses of recycled material (ISO 14041, 1998). For the plywood and LVL studies, all allocation is performed on a mass basis (CORRIM II, 2000). All the electricity, heat and emissions involved in the sub-process that created the by-product, are allocated. Allocation is performed on four machine centers (ones producing by-products): debarking/bucking, peeling/clipping, drying and trimming/sawing.

INCLUSIONS AND ASSUMPTIONS

Ideally, all inputs used in the manufacturing process are included in the analysis. From a practical standpoint, in regard to time and data availability, accounting for all material and energy flow is not possible. Material and energy inclusion are based on a defined percentage of the total consumption (ISO 14041, 1998). Any material or energy used in the process greater than or equal to two percent of the total consumption is the limit used, as defined by CORRIM II (CORRIM II, 2000). Furthermore, products that are considered extremely toxic and/or an environmental hazard would be included, even if less than two percent. Since data is not available for every material and energy flow, some assumptions are made.

Resin extenders and fillers are not included in the study. Typically, agricultural by-products, such as wheat flour, are used as extenders and fillers. For example, it is estimated that only about 8 kgs (18 lbs) of fillers and extenders (30% filler/extender solids, OD basis) go into a Msm 9-mm basis of plywood. This only accounts for approximately 1.5% of the total weight of the product. Based on the plywood numbers, it is assumed a m^3 of LVL would utilize fillers and extenders at no more than 2% of the final product weight.

Others materials considered are the packaging materials. Steel bands are calculated to weigh on a Msm 9-mm basis of plywood, approximately 0.1% of the final products weight (Appendix A). Solid wood stickers are estimated to weigh about 40.38 kg for Msm 9-mm basis of plywood, approximately 0.8% of the final products weight (Appendix A). Based on the plywood numbers, it is assumed a m^3 of LVL utilizes packaging materials no more than 2% of the total weight of the product.

No measurements or estimates were made for machinery lubrication. On a conceptual basis, it is assumed lubricant usage for plywood and LVL production is far below the 2% of the total weight rule.

Water use is considered. In both the liquid and vapor form, water is used occasionally throughout the process (i.e. log yard, conditioning). Waste water discharge, is a potential environmental concern. It is assumed that water is contained on site and only lost to evaporation (ATHENA, 1993). Steam from log conditioning and wood drying is returned to the environment as benign water vapor and therefore is excluded.

The last major ancillary material considered are capital equipment and buildings. Without them, manufacturing would not be possible, but they are not included in the study. Much energy and materials go into creating the physical equipment and buildings. Most likely, as much energy and materials go into creating the equipment as used to build the physical equipment and buildings. One can see how tracking this stream of energy and material flows is never ending. Therefore, the machinery equipment and building structures are excluded from this study.

These are not the only ancillary materials and energy flows involved in plywood and LVL manufacturing, but seem to be the most important and obvious. Adding these materials and considering many others not mentioned, this total fulfills the required 2% of the total consumption. Recognizing this, these materials are still excluded from the study. Once data is available on many of these materials and as LCA advances, a study should include them in any subsequent analysis.

DATA SOURCES

The most time consuming portion of a life cycle study is collecting the data for the Life Cycle Inventory. In order to perform this study in a timely manner, current manufacturing data is used. The majority of this secondary data originates from the National Council for Air and Stream Quality (NCASI), Franklin Associates, ATHENA™ Sustainable Materials Institute, Oregon Department of Energy (ODOE) and the Energy Information Administration.

NCASI's data is used for reporting all emissions produced through plywood and LVL manufacturing processes. NCASI began researching Hazardous Air Pollutants (HAP) and VOC emissions as part of a wood products Maximum Achievable Control Technology (MACT) study in response to the 1990 Clean Air Act. The purpose of the NCASI study is to provide data for the wood products industry and the Environmental Protection Agency (EPA) to set MACT standards. Two sets of NCASI technical bulletins are used as data sources (NCASI, 1999 and 1995). The early publication, published in 1995, generates emissions data for five Pacific Northwest and four southern softwood plywood mills (Appendix B). The 1999 publication, summarizing the results of the MCAT study, generates emissions data for three Pacific Northwest softwood plywood mills, three southern plywood mills and two southern LVL mills. NCASI selected mills based on the following criteria: recent flow diagrams, well-implemented processes with automated recordings of process parameters, operation stability, no unusual equipment, and a place where VOCs and HAPs could be sampled at the inlet and outlet of pollution control devices. These two publications are independent of each other.

A database created by the Franklin Associates is used for electricity, heat and natural resources data. Franklin Associates are known nationwide as LCI specialists and serve as consultants to public and private industries. Fifty-seven public and private sources, reports and conversations with LCA experts from the United States make up the data for the energy, heat and resource processes. These processes are inclusive of all down stream processes (i.e. resource extraction, material processing) and are considered cradle-to-gate processes.

The ATHENA™ Sustainable Materials Institute, generated from the ATHENA™ project initiated by Forintek Canada Corp, is dedicated to assisting the public to meet future environmental challenges. ATHENA's™ main purpose is to educate the building community on material mixes that promote sustainable development and minimize environmental impacts. ATHENA's™ data for phenolic-formaldehyde resin production is used (Forintek Canada Corp, 1993 for entire paragraph).

Some energy and heat consumption is estimated from a report published by the Oregon Department of Energy. Published in 1988, wood products production is the basis of the report (ODOE, 1988). This report is used by the ODOE for energy consumption estimations and conservation potential. This data represents the average of technology in Oregon.

Other energy data is provided by industrial sources. These sources provided current energy and electricity consumption data for two plywood and two LVL mills in the PNW and four plywood mills and one LVL mill in the southern region. This information also revealed their distribution of fuel sources used to generate heat.

The final major source of data comes from the Federal Department's Energy Information Administration. Using a report published 1997, which state energy fuel sources, the means for electrical utility generation are defined for the Pacific Northwest and southern production regions.

MODEL LIMITATIONS

Although these models are created in good conscience, some limitations are inherent. Limitations are expressed in regard to data availability and data aging.

Data collection is time consuming and ever changing, especially for emissions. The two sets of technical bulletins used for emissions from manufacturing vary in detail. The early reports provide general emissions data, NO_X, SO_X, CO, Volatile Organic Compounds (VOCs), and particulates, while the later provides detailed data on VOCs and Hazardous Air Pollutants (HAPs). As mentioned earlier, data do not exist for every material and energy flow involved.

Technology and resources change as time progresses. As technology advances, efficiency, productivity, and resource utilization usually improves. Furthermore, technological advances may reduce environmental and health impacts, especially if that is the goal. These improvements change resource consumption. Less energy may be required to process the same product in the future. Availability of resources also change.

For example, large timber is presently harder to obtain compared to the past. Oil discovery has slowly declined over the past two decades. At present, the oil discovery rate is about 6 Gigabarrels per year, while consumption is ten-fold of discovery (Campbell, 1998). As these resources change, so does the processes they support. As fuel sources change, particularly fossil fuels, so do the fuels used for electricity and heating. These changes provide opportunities for innovation and substitution.

In summary, these models, as with any, are only as good as the supporting data. Data needs to be collected on current and other pertinent processes. These data sets require constant updating, providing the means to enhance models.

BASE CASE INPUTS

INTRODUCTION

Four base cases are created in total from, plywood and LVL manufacturing in both the Pacific Northwest (Oregon and Washington) and the southern (Alabama, Mississippi, Georgia and Louisiana) resource regions of the United States. The most common standard product design is used for these structural components. Softwood, plywood sheathing is considered a 3-ply, 9-mm thick panel with phenol-formaldehyde resin. LVL is 38.1 mm, 13-ply construction with phenol-formaldehyde resin. The following parameters are based on available data.

PLYWOOD AND LVL MATERIAL PARAMETERS

A variety of wood species are processed for veneer in the Pacific Northwest (PNW). These species include Douglas-fir (*Pseudotsuga menziesii*), spruce (*Picea* spp.), western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*) and white fir (*Abies concolor*). Douglas-fir (DF) is the dominant species processed. The average oven-dry (OD) density of DF on the coast, interior west, north and south, 480 kg/m^3, is used to calculate material flows (FPL-USDA, 1999). Wood processed in the south is predominantly southern yellow pine (*Pinus* spp.). For this study this grouping consists of longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), slash pine (*Pinus elliottii*), pitch pine (*Pinus rigida*) and pond pine (*Pinus serotina*). The average OD densities of these species, 550 kg/m^3, is used to calculate material flows (FPL-USDA, 1999). Compressive forces during pressing increases product densification by a factor of 1.11 (Wellons, 1983). The LVL and plywood OD product density are calculated as 611 kg/m^3 for southern yellow pine (SYP) and 533 kg/m^3 for Douglas-fir.

In order to calculate the product wood weights, the following equation was used:

$$\text{OD Wood Density} * \text{OD Wood Volume} = \text{OD Wood Weight}$$

Table 1 below displays the approximate OD veneer weights for Msm 9-mm basis of plywood and m^3 of LVL.

Glue spreads, the amount of glue applied to the veneer, are needed to calculate the final product weights. The 3-ply plywood construction requires 2 glue lines while the 13-ply LVL construction requires 12 glue lines. Due to the porosity differences of various wood species, separate glue application rates are used for each species.

Table 1: Veneer weights for Msm 9-mm basis of plywood and m^3 of LVL.

Product	Species	OD Weight (kg.)
OD Veneer for Plywood	DF	4795
OD Veneer for Plywood	SYP	5497
OD Veneer for LVL	DF	528
OD Veneer for LVL	SYP	605

The estimated application rate for southern yellow pine is 105.5 kg/thousand square meters of single glue line (Msm 9-mm basis SGL) of OD resin solids (Neese, 2000). An application rate of 92.5 kg/Msm 9-mm basis SGL of OD resin solids is estimated for Douglas-fir (Hickney, 2000). Using the OD veneer and resin weights, the final OD weight was calculated with the following equation:

OD Weight of the Veneer + (Green Resin Weight * % Total Solids/100) =

OD Product Weight

Table 2 displays respective phenol-formaldehyde resin parameters for Msm 9-mm basis of plywood and m^3 of LVL.

The OD percent resin solids per final OD product weight for southern and Pacific Northwest plywood are 3.39% and 3.40%, respectively, and south and Pacific Northwest LVL are 4.91 % and 4.94%, respectively. The absolute resin amount is larger in the southern region than in the PNW (Table 2). The factors required for the production of phenol formaldehyde are included in Appendix C.

Table 2: Calculated resin solid and product weights for Msm 9-mm basis plywood and m^3 LVL.

Species	Product	Application Rate (kg/Msm 9-mm basis SGL of OD resin solids)	OD Resin Solids Weight (kg)	OD Product Weight (kg)
SYP	LVL	105.5	33	638
DF	LVL	92.6	29	557
SYP	Plywood	105.5	204	5701
DF	Plywood	92.6	173	4968

PLYWOOD AND LVL MATERIAL FLOWS

The approximate material required to produce a Msm 9-mm basis of plywood or m^3 of LVL is back-calculated from the final product weights (Figures 7,8,9,10).

Figure 7: Pacific Northwest plywood material flows to produce Msm 9-mm basis.

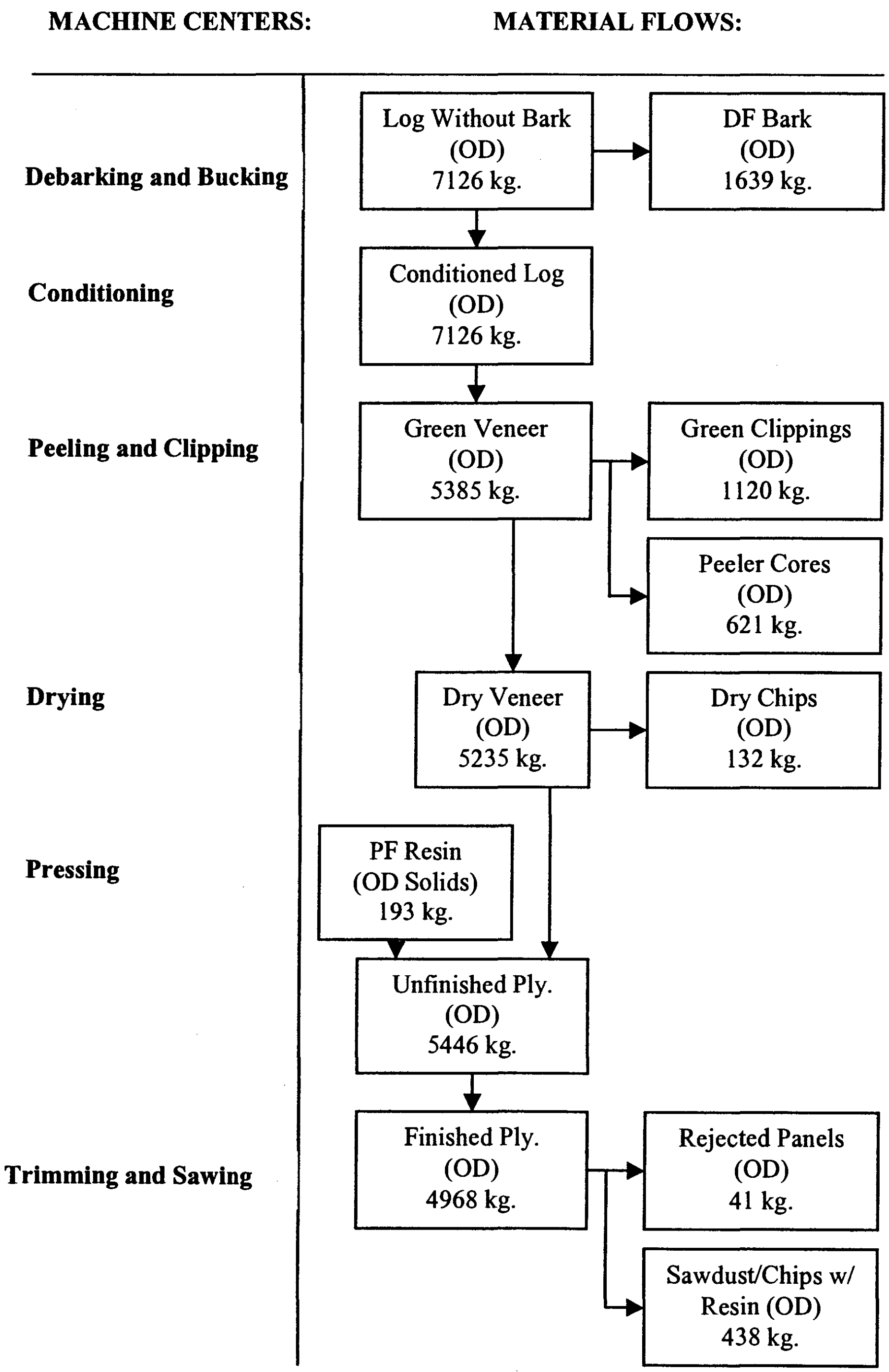


Figure 8: Pacific Northwest LVL material flows to produce m³.

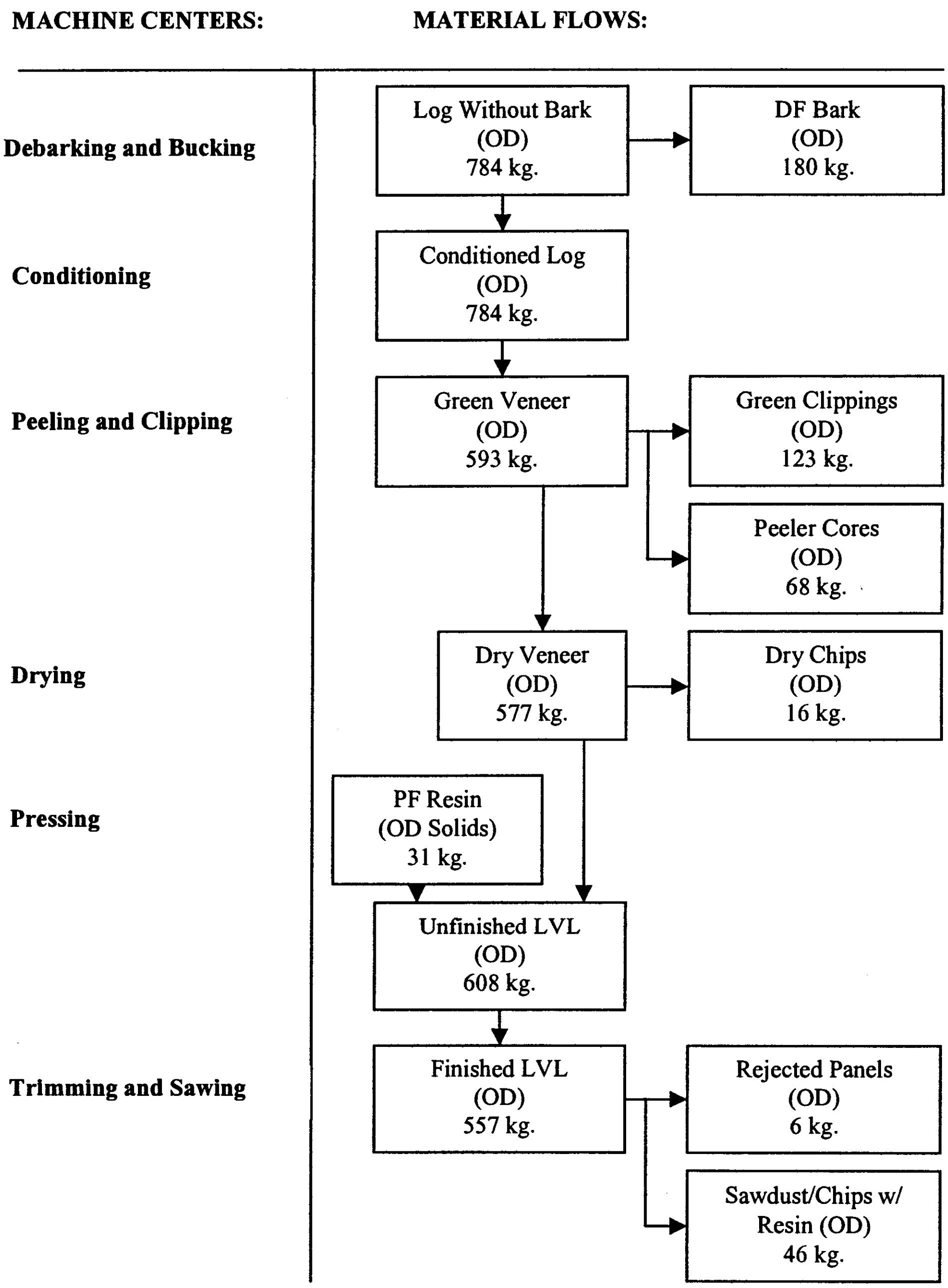


Figure 9: Southern plywood material flows to produce Msm 9-mm basis.

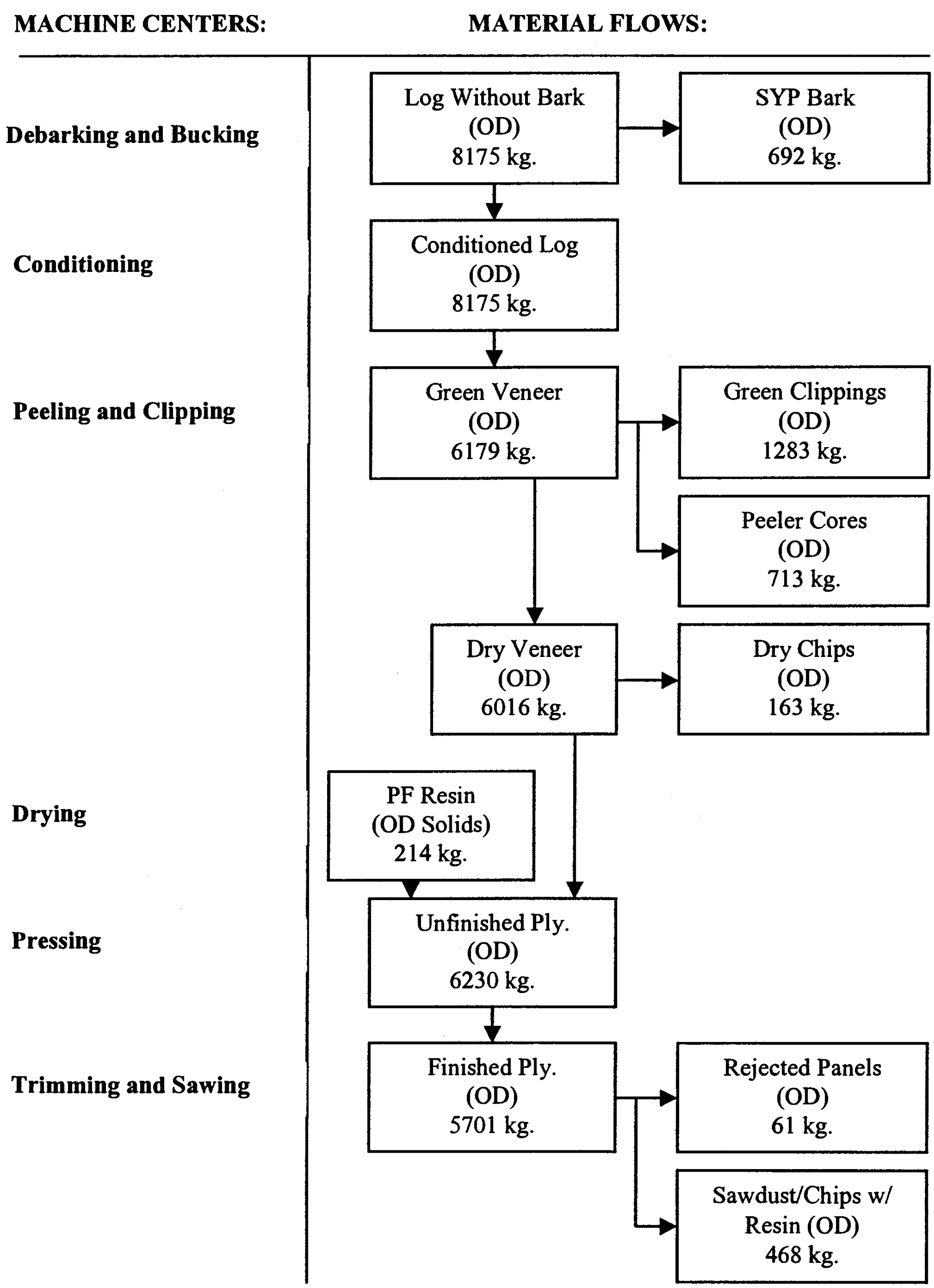
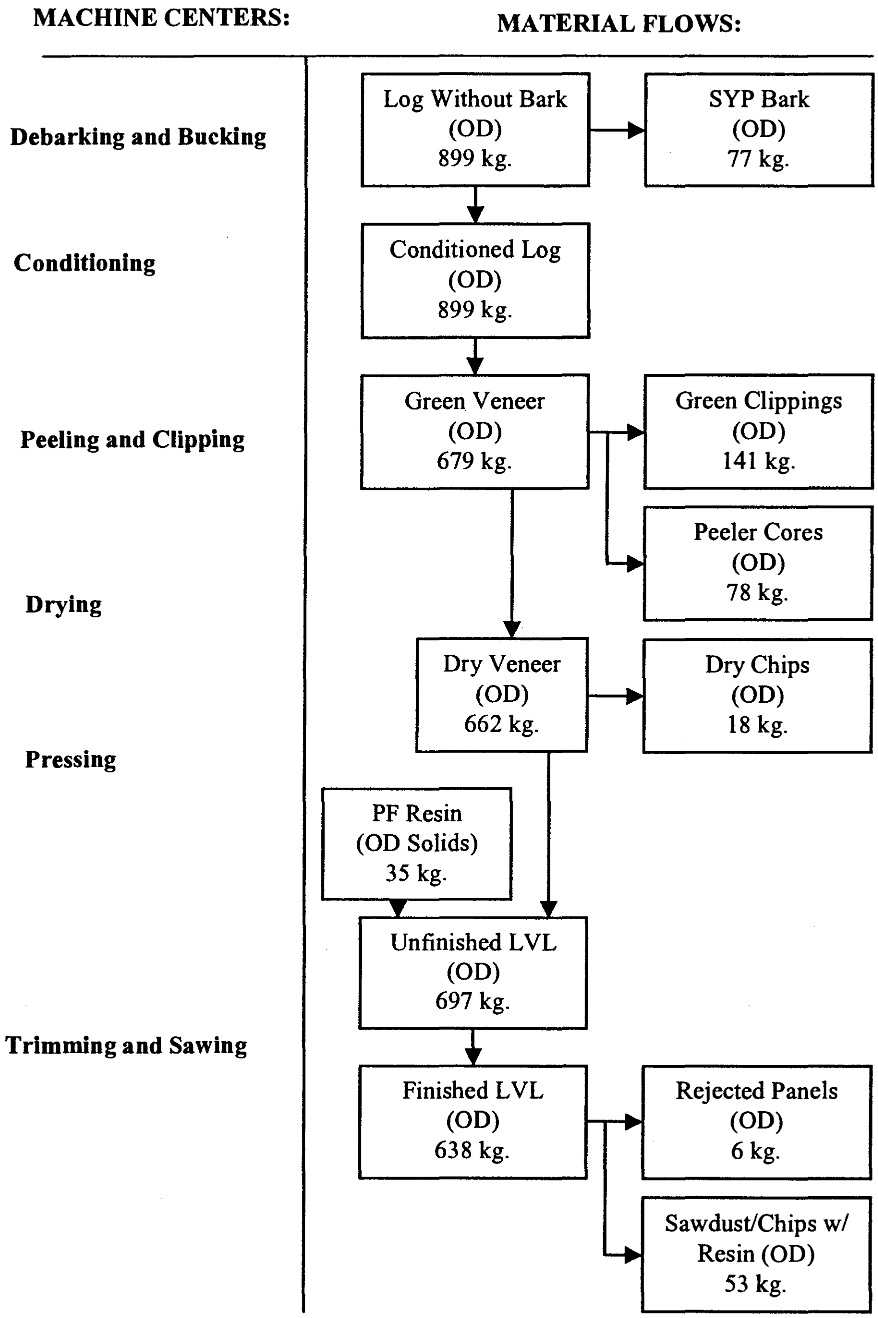


Figure 10: Southern LVL material flows to produce m^3.



Since allocation is performed on a mass basis, all products and by-products are calculated on an OD basis.

In order to calculate the material flows in this fashion, loss fractions are necessary for particular machine centers. The applied percentages are based on the wood necessary to produce the specified production units. Bark is the first by-product created at the debarking and bucking machine center. Southern yellow pine bark weight is estimated using the loblolly pine average values: 16% of the total log volume at an OD density of 320 kg/m^3 (Koch, 1972b). Douglas-fir bark is estimated at 28% of the total log volume at an OD density of 390 kg/m^3 (Briggs, 1994). The remaining percentages are based on the total wood required to produce the Msm 9-mm basis of plywood or m^3 of LVL. The breakdown is as follows: 15.70% lost to clipping and roundup, 8.70% lost to peeler cores, 1.98% lost to dryer scraps, 1.98% lost during lay-up, 3.72% lost to panel trim, and 0.51% lost to sawdust (Fahey, 1987). Two assumptions are made relating to these fractions: the products are trimmed back two inches around the perimeter and a saw with 3.18 mm kerf is used. A resin loss (as a by-product) estimate is calculated from the sum of the lay-up, panel trim and sawdust by-products percentages. 6.70% of the OD resin solids is required for the total loss. There is also assumed to be a 1% product rejection after all processing. Table 3 displays the percentage allocation to the by-products.

Table 3: Percentage allocation to by-products.

Products	Machine Center Allocation for By-products: Pacific Northwest (%)	Machine Center Allocation for By-products: South (%)
Bark	18.7	7.8
Green Clippings/Round-up	12.8	14.5
Peeler Cores	7.1	8.0
Dry Chips	1.6	1.8
Chips with Resin	4.6	5.3
Sawdust with Resin	0.5	0.5
Total	45.3	37.9

ELECTRICITY CONSUMPTION

Electricity use varies from machine center-to-machine center. Motors driving the machinery consume the greatest portion of the electricity. The challenge was distributing the electricity consumption to each machine center.

For the Pacific Northwest region, 5721 MJ and 630 MJ of electricity are required to produce Msm 9-mm basis of Douglas-fir plywood and m^3 of Douglas-fir LVL, respectively (Industry Source, 2000).

It is anticipated that electricity consumption in the southern portion of the United States is greater than the Pacific Northwest (PNW). This greater use is based on processing southern yellow pine which is denser and has a higher moisture content. The opposite was true, which most likely relates to the newer plywood facilities in the south. 4021 MJ are required to produce Msm 9-mm basis of southern yellow pine plywood basis and m^3 of southern yellow pine requires 436 MJ (Industry Source, 2000).

For both the PNW and south, additional electricity is required for pollution certain control devices. A WESP is used for dryer exhaust emissions in the PNW and requires 275 MJ /Msm 9-mm basis of plywood and 30 MJ m^3 of LVL (Raemhild, 2000). In the south, a RTO is used to control dryer stack emissions and requires 193 MJ/Msm 9-mm basis of plywood basis and 21 MJ/m^3 of LVL (Raemhild, 2000).

The distribution of electricity by machine center is calculated from reports on energy use in the forest products industry from Grist's and Karmous' (1988) and the Oregon State University Energy Extension Office (Appendix D). The generation of this data was prior to newer emissions control devices (i.e. RTO and RCO). Table 4 displays the electricity distribution by machine center.

Table 4: Allocation of electricity by machine center.

Machine Center	%
Debarking/Bucking	12.3
Conditioning	7.6
Peeling/Clipping	16.8
Drying	19.3
Chipping Dry Material	5.2
Pressing	11.5
Trimming/Sawing	10.1
Chipping Lay-up/Trim Scraps	17.2
Total	100.0

Generating energy requires a fuel source. Because resources, particularly fossil fuels, vary by geographical location, fuel source may differ from state-to-state. The major fuel sources considered are coal, natural gas, petroleum, nuclear, hydroelectric, and wood waste. Tables 5 and 6 depict the average estimates for energy inputs for electric utilities in the Pacific Northwest and southern regions. Particular state estimates are displayed in Appendix D. Note that coal and nuclear power are the predominant fuel source for the south, while hydroelectric power generates the majority of the electricity for the Pacific Northwest. Appendix E lists the distribution of the fuel sources for each machine center.

Table 5: Pacific Northwest estimates of fuel used for the electric utilities, 1997 (Energy Information Administration, 1999).

State	Coal	Natural Gas	Petroleum	Nuclear Electric Power	Hydroelectric Power	Wood Waste	Geothermal Energy	Total
Megajoules								
Oregon	1.52 E+10	1.14 E+10	1.05 E+08	0	5.08 E+11	0	0	5.38 E+11
Washington	8.08 E+10	2.85 E+09	2.11 E+08	6.99 E+10	1.11 E+12	3.79 E+09	0	1.27 E+12
Total	9.6 E+10	1.42 E+10	3.16 E+08	6.99 E+10	1.618 E+12	3.79 E+09	0	1.81 E+12
% of Total	5.3%	0.8%	0.0%	3.9%	89.5%	0.2%	0.0%	99.6%

Table 6: Southern estimates of fuel used for the electric utilities, 1997 (Energy Information Administration, 1999).

State	Coal	Natural Gas	Petroleum	Nuclear Electric Power	Hydroelectric Power	Wood Waste	Geothermal Energy	Total
Megajoules								
Alabama	7.53 E+11	1.09 E+10	1.37 E+09	3.31 E+11	1.25 E+11	0	0	1.22 E+12
Georgia	7.59 E+11	7.91 E+09	2.85 E+09	3.41 E+11	4.81 E+10	0	0	1.16 E+12
Louisiana	2.36 E+11	3.03 E+11	7.27 E+09	1.51 E+11	0	0	0	6.97 E+11
Mississippi	1.33 E+11	7.98 E+10	2.71 E+10	1.21 E+11	0	0	0	3.61 E+11
Total	1.88 E+12	4.01 E+11	3.86 E+10	9.44 E+11	1.73 E+11	0	0	3.44 E+12
% of Total	54.7%	11.7%	1.1%	27.5%	5.0%	0.0%	0.0%	100.0%

FUEL CONSUMPTION

Manufacturing of plywood and LVL with phenol-formaldehyde resin requires a heat input to cure these products. Heat also plays an important role in block conditioning and veneer drying. Heating the block softens the wood, which assists the peeling process. During veneer drying, heat provides the energy required to evaporate water from the wood to achieve the desired moisture content. For these models, fuel is used for three machine centers: conditioning, drying, and pressing, and for internal transportation (i.e. heavy equipment and forklifts). The fuel consumption required for plywood and LVL production depends on the wood species. Due to different species characteristics, such as green moisture content and specific gravity, southern yellow pine and Douglas-fir require different amounts of fuel during processing; southern yellow pine requiring the most.

In the Pacific Northwest, the fuel required to produce Msm 9-mm basis of plywood is measured to be 35,141 MJ (Industry Source, 2000). As was done for electricity, it is assumed that production unit weight and fuel consumption are directly proportional. Using this assumption, the fuel required for m^3 of LVL is calculated as 3,885 MJ.

Pollution control devices also require an additional heat input. In the southern region RTO's are the pollution control device used. RTO's require 1018 MJ/Msm 9-mm basis of plywood basis while 3,885 MJ is required to control emissions for m^3 of LVL (Raemhild, 2000).

In the south, the fuel required to produce Msm 9-mm basis of plywood is measured as 40,466 MJ (Industry Source, 2000). As was done for electricity, the assumption of production unit weight and fuel consumption being directly proportional applies. Using this assumption, the fuel required per m^3 of LVL is calculated as 4,452 MJ.

The three machine centers consume fuel with the following distribution: conditioning 30%, drying 55%, and hot pressing 15% (Forintek Canada Corp., 1993; Grist and Karmous, 1988). Until recently, the primary fuel source for heat was hogfuel. Hogfuel consists of wood and bark waste generated during the manufacturing process. In some cases, hogfuel was purchased as a cheap fuel source. In the 1980's, hogfuel made up 95% of the heating fuel source for the Pacific Northwest (Grist and Karmous, 1988). With the rise of concern in regard to emissions, cleaner burning fuel sources are desired. Currently fuel sources for the Pacific Northwest are 74% hog fuel, 23% natural gas, 2% Distillate Fuel Oil (DFO), and 1% Liquid Propane Gas (LPG) (Industry Source, 2000). In the south, fuel sources of 50% hog fuel, 48% natural gas, 1% DFO , and 1% LPG are typically used (Industry Source, 2000). These distributions, referred to as the "Industry Practice," are based on 3 mills each (Industry Source, 2000). Machine center fuel source distribution for each model is listed in the Appendix E.

Since both regions still use a considerable amount of hog fuel as a heating source, it is assumed the bark generated from the manufacturing processes was used as fuel (100% bark). Table 7 displays the heat generated for each process per its measurement unit (i.e. Msm 9-mm basis or m^3) (See Appendix A).

Table 7: Heat generated from using the bark by-product as a fuel source per Msm 9-mm basis of plywood and m^3 of LVL (Appendix A).

Manufacturing Process	Bark Amount (OD kg)	Heat Generated (MJ)
PNW Plywood	1639	4133
PNW LVL	180	454
South Plywood	692	1751
South LVL	77	193

CALCULATION METHODOLOGY: SIMAPRO

Created in The Netherlands, SimaPro is a software package created to help "analyze and develop environmentally sound products (PRe Consultants, 1999)." The LCA community recognizes PRe Consultants, the creators of SimaPro, as the leaders and experts in LCA and developing support software. This software package provides many tools and resources that can be used to analyze the plywood and LVL processes. SimaPro software, with an accompanying database, can be used to perform a detailed environmental impact analysis. Although environmental problems are heavily debated and complex, SimaPro attempts to give the user "clear insight into this complexity." For the plywood and LVL studies, SimaPro is used to calculate the list of inputs and outputs and perform a sensitivity analysis on specific parameters (PRe Consultants, 1999c). Furthermore, SimaPro can also provide qualitative output in terms of eco-indicators. The data and methodology of the SimaPro software are still under development, so all results are not considered an absolute truth (PRe Consultants, 1999c).

SimaPro is based on the most current ISO 14000 Standards. SimaPro is most useful during the inventory and impact assessment phases of an LCA. SimaPro acknowledges the importance of defining the scope and objectives of the project; as this first stage dictates all decisions made in the later stages.

Before describing the inventory analysis, the SimaPro manual discusses six common concerns with inventory analysis: system boundaries, generation of more than one product, avoided impacts, geographical variations, data quality, and choice of technology. System boundaries are often questioned when analyzing a process. For example, plywood manufacturing requires a dryer and hot press. Many components, such as steel and electronics, go into creating this equipment. It is not practical to account for the manufacturing processes in such detail, so capital goods are excluded. Processes generating more than one product allocate impacts on a mass, economic or environmental basis. Environmental bases refers to any substance that is toxic at any dosage. Moreover, processes that produce by-products create impacts but also save impacts, providing inputs to other processes. Such impacts are referred to as avoided impacts and are deducted from the process of origin. The Franklin Associates Database, included with the SimaPro software, represents fifty-seven private and public United States sources, reports, and conversations with experts. The type of technology used during manufacturing affects efficiency and material usage, thus affecting impacts. SimaPro contains data based on average technology.

This methodology uses three steps to perform the inventory analysis and the impact assessment: techno-sphere, eco-sphere and value-sphere. This procedure, developed by experts in Europe, is termed the Eco-indicator99 methodology (Goedkoop and Spriensma, 2000). A "sphere" is a field of scientific knowledge and reasoning (Hofstetter, 1998). Briefly, the techno-sphere describes the inventory analysis, eco-sphere is when the characterization (including classification) are performed, and finally the value-sphere step is where the normalizing and weighting occur. These models attempt to integrate technology and science. " The first two spheres [techno-sphere and eco-sphere] can be considered to be in the technical and natural science paradigms, the third sphere [value-sphere] is clearly in the social science world,... (Goedkoop and Spriensma, 2000)." So, as the methodology moves from step-to-step, the uncertainty and subjectivity grows. The weighting step (value-sphere) is the most critical and controversial step in LCA (Goedkoop and Spriensma, 2000). Table 8 describes the characteristics associated with each modeling step. The inventory analysis (techno-sphere) is basically a description of the life cycle. It accounts for all emissions created for the processes that occur during the life cycle of a product.

This includes resource extraction, manufacturing, transportation, use/reuse and disposal (the plywood and LVL study will only look at the manufacturing step). Once the techno-sphere step is completed, the eco-sphere step begins.

Table 8: Characteristics of the techno-, eco-, and value-spheres (PRe Consultants, 1999a).

Category	Techno-sphere	Eco-sphere	Value-sphere
Subject of Modeling	concrete technical systems	complex cause & effect chains	societal preference and values
Verification	possible in many cases	difficult/impossible	no single truth
Main Problems	boundaries and allocations	limited scientific understanding and availability of data	how to measure values in society and incompatible views
Uncertainties	low (less than one order of magnitude)	high (sometimes several orders of magnitude)	high

The eco-sphere begins the "modeling of changes (damages) that are inflicted on the environment (Goedkoop and Spriensma, 2000). During the eco-sphere phase the results from the inventory analysis are classified and characterized into one of three damage categories: human health, ecosystem quality, and resources. These categories, or indicators, are the same as specified in the ISO 14042 standards (referred to as endpoints).

Human health is described as "the idea that all human beings, in the present and future, should be free from environmentally transmitted illnesses, disabilities or premature deaths (Goedkoop and Spriensma, 2000)." The emissions classified into the human health damage category is measured (or characterized) in terms of disability adjusted life years (DALYs). DALYs are "indicators of the time lived with a disability and the time lost due to premature death (Homedes, 1995)." "A damage of 1 means one life year of one individual is lost, or one person suffers four years from a disability with a weight of 0.25 (Goedkoop and Spriensma, 2000)." The human health category considers carcinogenic effects on humans (Carcinogens), respiratory effects on humans caused by organic substances (Respiratory Organic), respiratory effects on humans caused by inorganic substances (Respiratory Inorganic), damages to human health caused by climate change (Climate Change), human health effects caused by ionizing radiation (Ionizing Radiation), and human health effects caused by ozone layer depletion (Ozone Layer) (Goedkoop and Spriensma, 2000). Emissions included in each category are listed in Appendix F.

Ecosystem quality is described by "the idea that non-human species should not suffer from disruptive changes of their population and geographical distribution (Goedkoop and Spriensma, 2000)." The emissions classified into the ecosystem quality damage category are characterized as PDF * m^2 * yr (Potentially Disappeared Fraction of Species). "A damage of 'one' means all species disappear from 1 m^2 during one year, or 10% of all species disappear from 10 m^2 during one year, or 10% of all species disappear from 1 m^2 during 10 years (Goedkoop and Spriensma, 2000)." The ecosystem quality category considers damage caused by ecotoxic emissions (Ecotoxicity), caused by the combined effect of acidification and eutrophication (Acid/Eutrophication), and caused by land occupation and land conversion (Land-use). Ecotoxicity "describes the presence of all species present in the environment living under toxic stress (PRe Consultants,1999c)." Acidification describes the "sulfur, nitrogen oxides and ammonia that cause a build-up of acidity in the soil (PRe Consultants, 1999c)." Eutrophication refers to "phosphate and the same substances that cause acidification can result in a kind of 'over-fertilization,' an excess accumulation of nutrients in the ground (PRe Consultants,1999c)." Emissions included in each category are listed in Appendix F. Ecosystem quality does not include any assessment of the depletion of the salmon run in the Pacific Northwest.

The resource category "contains the idea that nature's supply of non-living goods, which are essential to the human society, should be available also for future generations (Goedkoop and Spriensma, 2000)." The resource endpoint is measured via MJ surplus energy. "A damage of one [indicator point] means that due to a certain extraction, further extraction of this resources in the future will require one additional MJ of energy... (Goedkoop and Spriensma, 2000)." This indicator considers damage caused by the extraction of minerals (Minerals) and fossil fuel (Fossil Fuels). Resources included in each category are listed in Appendix F.

Detailed information on how DALYs, PDFs, and MJ surplus energy is calculated, can be found in the Eco-indicator methodology report (Goedkoop and Spriensma, 2000).

During the value-sphere phase, the "seriousness" of the damages are determined for the two previous steps (Goedkoop and Spriensma, 2000). The value-sphere phase is when the normalizing and weighting of the three endpoints occurs. The normalization factor is created from the total emissions and resource consumption in the European and Dutch geographical area over a period of a year is divided by the population of that region (Goedkoop and Spriensma, 2000). The normalized value is obtained when the damage factor is divided by the normalized factor (Table 9). The weighting of the three groups are derived from surveys sent to various interest groups. Based on the interest groups responses, they were categorized into one of three groups: hierarchists, individualists or egalitarians. Table 10 describes the characteristics of each interest group.

Based on survey results, individualists value human health the most. Ecosystem quality is paramount to the egalitarian's interests. Hierarchists place an equal emphasis on both human health and ecosystem quality. SimaPro created a methodology based

Table 9: Normalizing and weighting factors for the three damage categories (Goedkoop and Spriensma, 2000).

	Normalization	Weights
Human Health	1.54 E-02	400
Ecosystem Quality	5.13 E+03	400
Resources	8.41 E+03	200

on each group's interests. The methodology based on the hierarchists is used for this study, as suggested by SimaPro software. The weighting applied is as follows: human health (40%), ecosystem quality (40%), and resources (20%) (Table 9). Multiplying the weighting factor listed in Table 9 by the normalized value yields the indicator point. The indicator point value is referred to as a score, as it is used to compare processes created with the same methodology and protocol. The higher the score, the greater impact on the environment. Appendix F lists the damage factors, normalized damaged factors and the weighted damage factors for every substance included in the hierarchist version of the Eco-indicator99 methodology.

There was initial concern of using the software because of its origin. The methodology for the impact assessment is based on European opinion and data. This study involves manufacturing data in the United States. This concern is eased after discussing the software's intended use with an LCA expert and SimaPro representative for the United States (Norris, 2000).

Table 10: Characteristics of the surveyed interested groups (PRe Consultants, 1999c).

Group	Time Perspective	Manageability	Required Level of Evidence
Hierarchists	balance between short and long term	proper policy can avoid many problems	inclusion based on consensus
Individualists	short term	technology can avoid many problems	only proven effects
Egalitarians	long term	problems lead to catastrophe	all possible effects

RESULTS AND DISCUSSION

The following sections present the results and discussion for the inventory analysis and impact assessment of the four base cases, by region. Full details about the base cases are presented in the system boundaries and base case inputs sections.

Key attributes of these base cases are the use of a pollution control devices and the heating fuel source. In the PNW, WESPs are primarily used for dryer stack emissions, and heating fuel sources consisting of 74% hog fuel, 23% natural gas, 2% Distillate Fuel Oil (DFO), and 1% Liquid Propane Gas (LPG). In the southern region, RTOs are primarily used for dryer stack emissions and heating fuel source distribution of 50% hog fuel, 48% natural gas, 1% DFO, and 1% LPG.

For each base case, a sensitivity analysis is performed on the following two parameters: pollution control device and heating fuel source. In the PNW, comparisons are made for operating with and without a WESP. In the southern region, RCOs are compared to RTOs along with a comparison of operating without either pollution control device. For both regions, alternative fuel sources for heating are compared to the "industry practice" stated above: either 100% hog fuel or 100% natural gas.

Key highlights of the inventory and impact assessment are the primary focus. For the inventory analysis, an abbreviated list of emissions is presented and considered essential to all industry evaluations (CORRIM II, 2000). The complete substance lists for all process and energy inputs and outputs for the selected scenarios are presented under Appendix G. All steps of the impact assessment–classifying and characterizing, normalizing and weighting–were performed, but only selected steps are presented. Because the methodology used is still under development, certain substances are not included in the impact assessment. These substances are marked on the complete emissions lists in Appendix G.

Certain emissions groups need clarification as they are not grouped by chemical composition: biochemical oxygen demand, suspended solids, dissolved solids and solid waste.

Biochemical oxygen demand (BOD) is generated from effluents containing organic materials. BOD determines the amount of oxygen required by the aerobic bacteria to digest the organic waste. A high BOD measurement reduces water quality for consumption and marine life (CORRIM II).

Suspended solids are produced by mining, milling, and/or processing operations which release insoluble particles that suspended in effluent. Dissolved solids are produced from mining, milling, and/or processing operations which release soluble particles. Suspended and dissolved solids also reduce water quality for human consumption and aquatic organisms (CORRIM II).

Solid waste is defined as by-products that are not used in the process or any other process and are stored or land-filled (i.e. ash or slag) (CORRIM II). Unfortunately, SimaPro groups all these by-products into a solid waste category.

PACIFIC NORTHWEST DRYING MACHINE CENTER

The first attribute analyzed is the drying machine center. In review, the drying machine center includes veneer drying, re-drying, and cooling and dry scrap chipping. Table 11 displays all emissions associated with the drying machine center for the base case and without-a-WESP case.

Table 11: Comparing the quantitative emissions for the base case drying machine center (includes a WESP) to a drying machine center without a WESP for both plywood and LVL in the PNW region.

	Plywood		LVL	
	No WESP (kg/Msm 9-mm basis)	WESP (kg/Msm 9-mm basis)	No WESP (kg/m^3)	WESP (kg/m^3)
Air Emissions:				
CO	1.001 E+01	1.001 E+01	1.101E+00	1.101 E+0
CO_2	1.736 E+03	1.736 E+03	1.906 E+02	1.907 E +02
N_2O	7.897 E - 05	8.929 E -05	9.373 E -06	1.031 E -05
NO_x	2.400 E +00	2.405 E +00	2.637 E-01	2.642 E-01
SO_x	3.959 E +00	3.974 E +00	4.358 E-01	4.372 E-01
Methane	7.279 E-01	1.207 E -01	8.026 E-02	8.026 E-02
Particulates	2.127 E-01	7.639 E -01	2.344 E -02	8.379 E-02
Water Emissions:				
BOD	5.729 E-03	5.729 E-03	6.269 E-04	6.269 E-04
Dissolved Solids	1.079 E-01	1.084 E-01	6.328 E-01	6.328 E-01
Suspended Solids	5.780 E+00	5.780 E+00	1.189 E-02	1.195 E-02
Land Emissions:				
Solid Waste	7.587 E+01	7.639 E+01	8.379 E+00	8.379 E+00

In every major air, water, and solid emissions category, for both plywood and LVL, there is a either no change or a slight increase in emissions when using a WESP. Particulates would be expected to decrease with the use of a WESP. Table 11 displays an approximate increase of 300%. This result should be ignored, as particulates were not measured for the no WESP dryer emissions. Those particulates listed come from the generation of energy. The generation of energy, electricity and heat, refers to all inputs and outputs associated with the mining of the minerals or fuels, the refining, and combustion of those minerals or fuels. Effective particulate control is seen in the southern region.

Looking at specific VOC emissions, certain trade-offs are apparent when comparing the base case machine center and the machine center without the WESP. In particular, for the base case machine center for plywood and LVL had an overall reduction of formaldehyde (47%), xylene (38%), acetone (31%), toluene (14%), and methyl i-butyl ketone (9%). On the other hand, some major VOC increases were vinyl chloride (40%), acrolein (26%), benzene (12%), N_2O (12%), tetrachloroethane (12%), and trichloroethene (12%). The complete drying machine center comparison for plywood and LVL is presented in Appendix G.

This slight increase in emissions is attributed to the extra electricity consumption required for the WESP, approximately 275 MJ/Msm 9-mm basis of plywood and 30 MJ/m^3 of LVL. It appears the emissions produced through generating the electricity to operate the WESP negates any emissions controlled by it. If the hydroelectric power, a clean fuel source, did not represent 89.5% (from Table 5) of the generated electricity in the PNW, the change of emissions in the WESP category would be higher. This is also displayed in the southern region results. The complete substance list for generating 1 MJ of electricity from coal, DFO, natural gas, and uranium are presented in Appendix G.

From the inventory analysis, the impact assessment is performed. Table 12 displays the final results of the impact assessment comparing the two drying machine centers, which shows no real differences. Both plywood and LVL in the PNW have no score from radiation, land-use, or mineral damage categories. Three damage categories make up approximately 93% of the total score: Respiratory Inorganic (21%), Climate Change (18%), and Fossil Fuels (54%).

Table 12: Comparing the environmental impact scores for the base case drying machine center (includes a WESP) to a drying machine center without a WESP for both plywood and LVL in the PNW region.

	Plywood		LVL	
	No WESP (Point/Msm 9-mm basis)	WESP (Point/Msm 9-mm basis)	No WESP (Point/m^3)	WESP (Point/m^3)
Carcinogens	0.803	0.798	0.088	0.088
Respiratory Organic	0.415	0.427	0.046	0.047
Respiratory Inorganic	11.127	11.178	1.230	1.230
Climate Change	9.529	9.581	1.055	1.055
Radiation	0.000	0.000	0.000	0.000
Ozone Layer	0.499	0.490	0.055	0.054
Ecotoxicity	1.133	1.150	0.125	0125
Acid/Eutrophication	1.385	1.391	0.153	0.153
Land-Use	0.000	0.000	0.000	0.000
Minerals	0.000	0.000	0.000	0.000
Fossil Fuels	29.258	29.309	3.222	3.228
Total	54.150	54.324	5.974	5.981

Comparing the drying machine centers shows little variation. The total score for the base case machine center increases less than one percent in comparison to the machine center without a WESP. Recall that the higher the score, the worse the effect the process has on the environment. The Respiratory Inorganic damage category increased approximately 2.6% when using a WESP. This increase is attributed to the rise in NO_X and SO_X emissions produced during the generation of the required extra electricity. There was a decrease of approximately 1.8% for the Ozone Layer damage category for the base case drying machine center. This is caused by the reduction in methyl bromide compared to the machine center without a WESP (see Appendix G).

SOUTHERN DRYING MACHINE CENTER

Looking at the southern region, the base case drying machine center (including a regenerative thermal oxidizer (RTO)) is compared to a drying machine without a RTO. A regenerative catalytic oxidizer (RCO) is also analyzed. The RCO requires 153 MJ of electricity and 305 MJ of heat per Msm 9-mm basis of plywood and 17 MJ of electricity and 27 MJ of heat per m^3 of LVL to operate (Raemhild, 2000). The RCO comparison involves emissions from two dryers; one indirect steam heated dryer (industry practice heating) and one natural gas direct-fired dryer.

Table 13 displays the major emissions for the RTO comparison. For the plywood and LVL drying machine centers, the RTO effectively controlled particulates, a reduction of 95%, while N_2O increased. All other major air, water, and land emissions slightly increased but showed no real difference for the machine center with the RTO. As seen in the PNW drying machine center comparison, a trade-off for VOC emissions is apparent. The machine center with an RTO reduced alkenes (61%), methanol (55%), acetaldehyde (32%), acetone (27%), and o-xylene (17%). Those emissions that showed substantial increase include tetrachloroethene (19%), trichloroethene (19%), dioxin (TEQ) (18%), and tetrachloromethane (15%). The complete drying machine center substance list is posted in Appendix G.

Table 13: Comparing the quantitative emissions for the base case drying machine center (includes a RTO) to a drying machine center without a RTO for plywood and LVL in the southern region.

	Plywood		LVL	
	No RTO (kg/Msm 9-mm basis)	RTO (kg/Msm 9-mm basis)	No RTO (kg/m^3)	RTO (kg/m^3)
Air Emissions:				
CO	8.80 E+00	9.33 E+00	9.66 E-01	1.03 E+00
CO_2	1.81 E+03	1.90 E+03	1.98 E+02	2.08 E+02
N_2O	5.08 E-04	6.03 E-04	5.57 E-05	6.62 E-05
NO_X	3.36 E+00	3.55 E+00	3.71 E-01	3.89 E-01
SO_X	9.69 E+00	1.02 E+01	1.07 E+00	1.12 E+00
Methane	1.90 E+00	2.11 E+00	2.08 E-01	2.31 E-01
Particulates	5.72 E+00	2.99 E-01	6.30 E-01	3.29 E-02
Water Emissions:				
BOD	1.37 E-02	1.44 E-02	1.50 E-03	1.58 E-03
Dissolved Solids	1.41 E+01	1.47 E+01	1.54 E+00	1.62 E+00
Suspended Solids	2.87 E-01	3.05 E-01	3.15 E-02	3.36 E-02
Land Emissions:				
Solid Waste	8.57 E+01	9.15 E+01	9.45 E+00	1.00 E+01

The RTO was effective in controlling particulates and certain VOCs. All other emission increases are associated with the 193 MJ and 1018 MJ per Msm 9-mm basis of plywood basis and 21 and 112 MJ per m^3 of LVL for electricity and heat, respectively, for operation. Appendix G displays the substance lists for generating the electricity and heat. The increases are more evident in the southern region compared to the PNW because of the heat required for the oxidation of air pollutants.

The RTO drying machine center comparison impact assessment results are displayed in Table 14. Similarly to the PNW, three damage categories make up approximately 93% of the total environmental score: Respiratory Inorganic, Climate Change, and Fossil Fuels. These categories are the major contributors because of the large amounts of CO_2, NO_X, and SO_X produced while generating electricity and heat from fossil fuels. Because of the extra energy required to operate the RTO, the impacts

Table 14: Comparing the environmental impact scores for the base case drying machine center (includes a RTO) to a drying machine center without a RTO for both plywood and LVL in the southern region.

	Plywood		LVL	
	No RTO (Point/Msm 9-mm basis)	RTO (Point/Msm 9-mm basis)	No RTO (Point/m^3)	RTO (Point/m^3)
Carcinogens	1.450	1.515	0.160	0.167
Respiratory Organic	1.550	0.695	0.171	0.076
Respiratory Inorganic	21.514	22.693	2.368	2.495
Climate Change	10.020	10.551	1.107	1.160
Radiation	–	–	–	–
Ozone Layer	0.241	0.202	0.027	0.022
Ecotoxicity	0.925	0.967	0.102	0.107
Acid/Eutrophication	2.281	2.405	0.252	0.265
Land-Use	–	–	–	–
Minerals	–	–	–	–
Fossil Fuels	53.048	55.583	5.842	6.124
Total	91.031	94.609	10.027	10.417

caused by these three damage categories, along with Carcinogens, Ecotoxicity, and Acid/Eutrophication, increased. The effective VOC control is exhibited with a decrease in the Respiratory Organic and Ozone Layer impact damage categories. The total impact assessment score is slightly higher for the drying machine center with the RTO than without the RTO for the plywood and LVL manufacturing processes, by approximately 3.7%.

Table 15 shows the results of RCO comparison. The drying machine centers with an RCO shows a reasonable reduction in CO and particulates compared to the machine center without an RCO. An increase in all other major categories (CO_2, N_2O, NO_X, SO_X, methane, BOD, suspended and dissolved solids, and solid waste) occurs when using the RCO, but only the N_2O stands out. The RCO drying machine center contributes to a number of reductions and increases in VOCs. Reductions included: alkenes (50%), methanol (46%), toluene (26%), benzene (25%), and acrolein (23%). Increases included: acetaldehyde (40%), phenol (16%), and dioxin (TEQ) (14%). The complete substances list is posted in Appendix G.

The impact assessment displays the effect of these emission increases and decreases. Table 16 exhibits the scores for the RCO comparison. Utilizing an RCO only reduces the impact of the Respiratory Organic damage category. This reduction is attributed to the reduction in certain VOC emissions. All other damage categories increased slightly due to the emissions associated with the augmented energy for the RCO.

Table 15: Comparing the quantitative emissions for a drying machine center with a RCO to a drying machine center without a RCO (emissions from one natural gas direct-fired dryer and one indirect steam heated dryer) for plywood and LVL in the southern region.

	Plywood		LVL	
	No RCO (kg/Msm 9-mm basis)	RCO (kg/Msm 9-mm basis)	No RCO (kg/m^3)	RCO (kg/m^3)
Air Emissions:				
CO	9.92 E +00	8.86 E+00	1.09 E+00	9.73 E-01
CO_2	1.77 E+03	1.84 E+03	1.96 E+02	2.01 E+02
N_2O	5.06 E-04	5.80 E-04	5.57 E-05	6.37 E-05
NO_x	3.33 E+00	3.44 E+00	3.64 E-01	3.78 E-01
SO_x	9.39 E+00	9.29 E+00	1.03 E+00	1.09 E+00
Methane	2.09 E+00	2.35 E+00	2.29 E-01	2.58 E-01
Particulates	4.14 E+00	2.91 E-01	4.55 E-01	3.20 E-02
Water Emissions:				
BOD	1.33 E-02	1.39 E-02	1.45 E-03	1.53 E-03
Dissolved Solids	1.36 E+01	1.43 E+01	1.49 E+00	1.57 E-02
Suspended Solids	2.77 E-01	2.96 E-01	3.05 E-02	3.26 E-02
Land Emissions:				
Solid Waste	8.51 E+01	8.86 E+01	9.31 E+00	9.73 E+00

Table 16: Comparing the environmental impact scores for a drying machine center with an RCO to machine center without a RCO (emissions from one natural gas direct-fired dryer and a drying one indirect steam heated dryer) for plywood and LVL in the southern region.

	Plywood		LVL	
	No RCO (Point/Msm 9-mm basis)	RCO (Point/Msm 9-mm basis)	No RCO (Point/m^3)	RCO (Point/m^3)
Carcinogens	1.415	1.479	0.156	0.163
Respiratory Organic	1.291	0.737	0.142	0.081
Respiratory Inorganic	20.983	21.986	2.307	2.421
Climate Change	9.961	10.256	1.093	1.134
Radiation	0.000	0.000	0.000	0.000
Ozone Layer	0.227	0.243	0.025	0.027
Ecotoxicity	0.925	0.938	0.101	0.103
Acid/Eutrophication	2.240	2.334	0.246	0.257
Land-Use	0.000	0.000	0.000	0.000
Minerals	0.000	0.000	0.000	0.000
Fossil Fuels	51.516	53.874	5.668	5.930
Total	88.558	91.847	9.739	10.116

PACIFIC NORTHWEST PLYWOOD AND LVL PROCESSES

Three different heating fuel source distributions were looked at for the entire plywood and LVL processes in the PNW: the "industry practice," as stated earlier, 100% hog fuel, and 100% natural gas. Table 17 shows the major emissions for both the plywood and LVL processes with the different heating fuel sources. Figure 11 and 12 show the increasing or decreasing trends with the natural log of the reported emissions when switching to either hog fuel or natural gas as a heating fuel source.

Table 17: Comparing the quantitative emissions for the plywood and LVL manufacturing with different fuel sources for heating in the PNW region.

	Plywood		
	100% Hog Fuel (kg/Msm 9-mm basis)	100% Natural Gas (kg/Msm 9-mm basis)	Industry Practice (kg/Msm 9-mm basis)
Air Emissions:			
CO	2.16 E+01	2.63 E+00	1.66 E+01
CO_2	3.51 E+03	1.95 E+03	3.12 E+03
N_2O	3.06 E-04	5.10 E-04	3.41 E-04
NO_x	4.72 E+00	7.33 E+00	5.32 E+00
SO_x	4.98 E+00	3.49 E+01	1.19 E+01
Methane	9.19 E-01	6.55 E+00	2.21 E+00
Particulates	1.05 E-01	1.04 E+01	1.05 E+01
Water Emissions:			
BOD	6.19 E-03	5.00 E-02	1.66 E-02
Dissolved Solids	6.71 E+00	5.21 E+01	1.71 E+01
Suspended Solids	3.49 E-02	8.46 E-01	2.23 E-01
Land Emissions:			
Solid Waste	1.57 E+02	8.57 E+01	1.37 E+02

	LVL		
	100% Hog Fuel (kg/m3)	100% Natural Gas (kg/m^3)	Industry Practice (kg/m^3)
Air Emissions:			
CO	2.43 E+00	3.46 E-01	1.88 E+00
CO_2	4.06 E+02	2.33 E+02	3.63 E+02
N_2O	3.74 E-05	5.68 E-05	4.28 E-05
NO_x	4.98 E-01	7.85 E-01	5.63 E-01
SO_x	7.95 E-01	4.07 E+00	1.56 E+00
Methane	1.46 E-01	7.68 E-01	2.89 E-01
Particulates	1.25 E+00	1.24 E+00	1.25 E+00
Water Emissions:			
BOD	1.01 E-03	5.81 E-03	2.14 E-03
Suspended Solids	1.09 E-03	9.43 E-02	2.74 E-02
Dissolved Solids	4.83 E-03	6.09 E+00	2.24 E+00
Land Emissions:			
Solid Waste	1.80 E+01	1.02 E+01	1.58 E+01

Figure 11. Comparing the natural log of the quantitative emissions for different heating fuel sources when manufacturing Msm 9-mm basis plywood in the PNW.

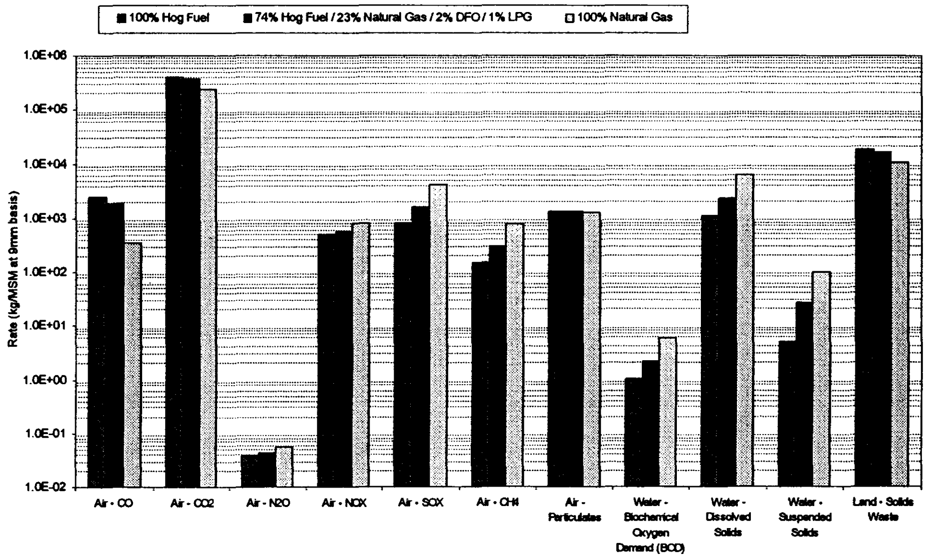
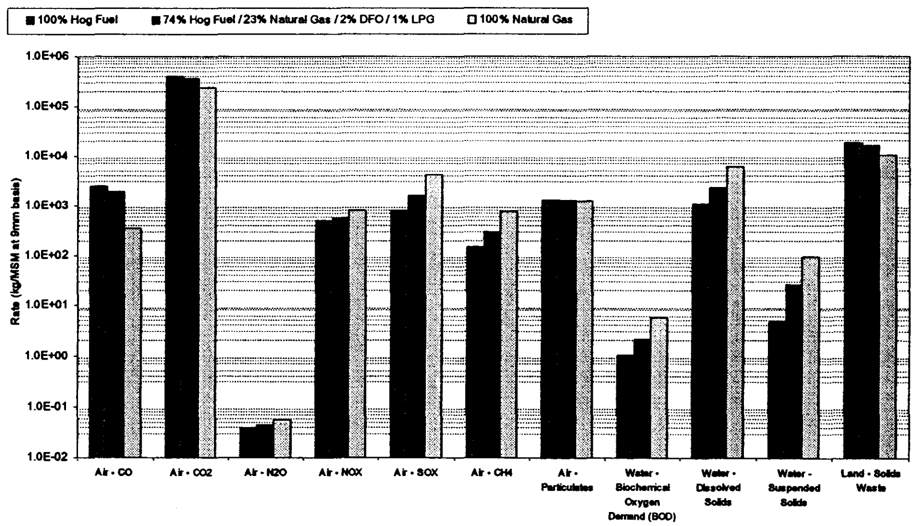


Figure 12. Comparing the natural log of the quantitative emissions for different heating fuel sources when manufacturing LVL in the PNW.



Switching fuel sources from the industry practice to hog fuel increases the rate at which CO_2, CO, and solid waste (which includes ashes) are created, but decreases the production rate of SO_X, NO_X, methane, BOD, suspended and dissolved solids. Using natural gas as a fuel source has the opposite effect, increasing SO_X, NO_X, methane, BOD, suspended and dissolved solids, while decreasing the production rate of CO_2, CO, and solid waste. The emissions and substance list for generating 1MJ of energy (heat), can be seen in Appendix G. The quantity and type of emissions created during energy generation from bark can vary. Various substances can be present in the bark that are not mentioned in this thesis.

After the inventory analysis, the impact assessment can be performed. Figure 13 and 14 displays the results of the characterization steps for the three different heating fuel sources for plywood and LVL. These figures show 100% of the total machine centers contribution to the specific damage category. The amounts, before the normalizing and weighting, are displayed proportionally by machine center for each damage category. For all six scenarios, three machine centers account for the majority of the total percentage of the carcinogens, respiratory inorganic, climate change, ecotoxicity, acid/eutrophication and fossil fuels damage categories, they are: conditioning, drying, and hot pressing. Conditioning, drying, hot pressing, and trimming and sawing account for the majority of the other two damage categories: respiratory and ozone layer. These results are attributed to the energy consumption, both electricity and heat, of the four machine centers.

Figure 13. Characterization of the damage categories for the different heating fuel sources by machine center for Msm of plywood in the PNW.

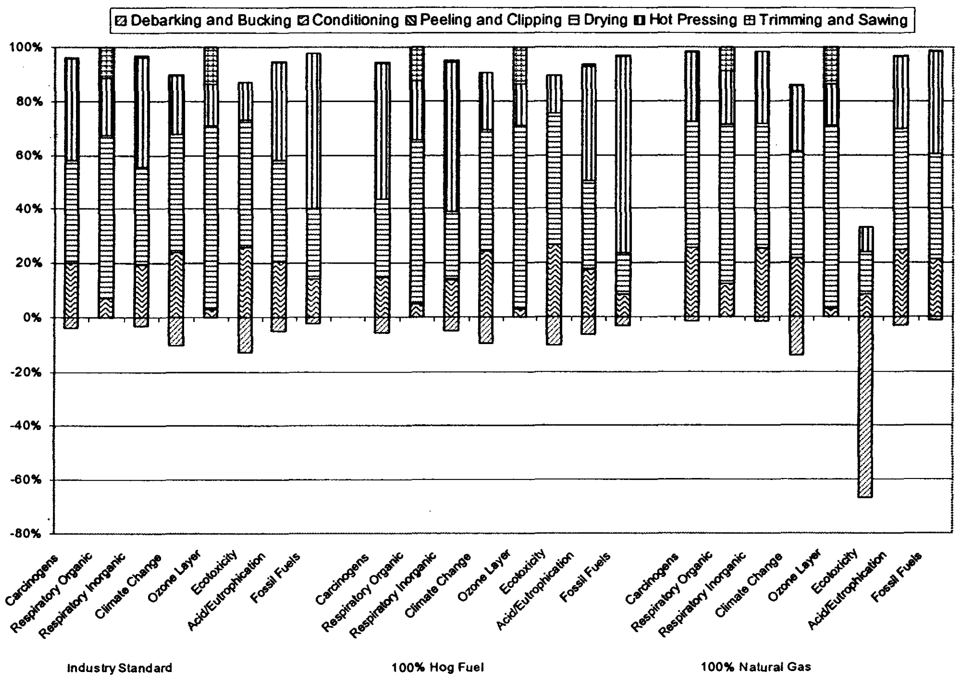
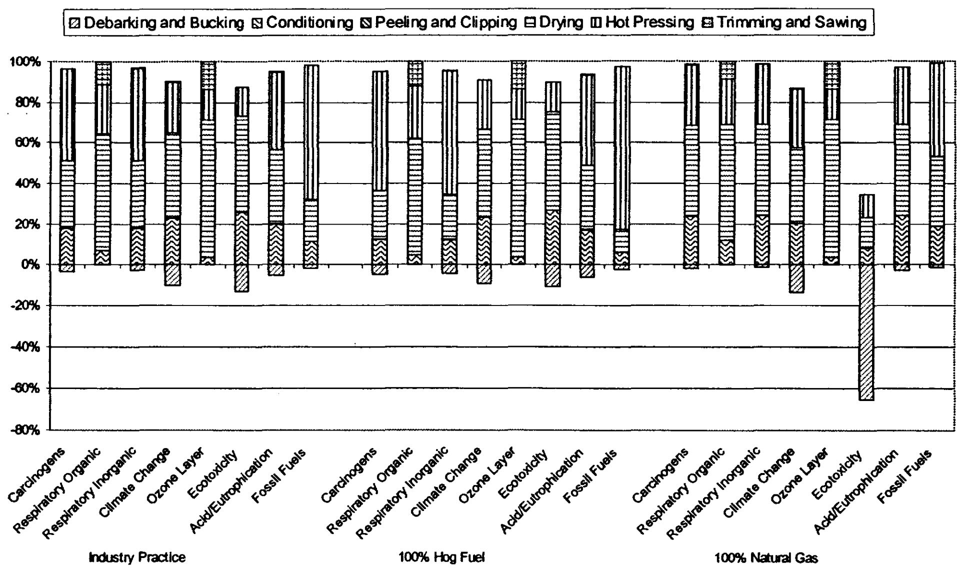


Figure 14. Characterization of the damage categories for the different heating fuel sources by machine center for the PNW.



The debarking and bucking machine center serves as a significant credit to the carcinogens, respiratory inorganic, climate change, ecotoxicity, acid/eutrophication, and fossil fuels damage categories. A credit is the result of the recycling or use of by-products generated during the manufacturing process. This credit is attributed to the generation of heat from the bark residue. More specifically, during the debarking and bucking machine center, bark is produced as a by-product. Based on the allocation rules discussed in the Plywood and LVL Modeling section, a percentage of the utilities used during the debarking and bucking machine center is allocated to the bark by-product. These utilities serve as a credit because the bark, or any by-product not going to landfill, will be used as an input to another process. So, those utilities or emissions subtracted from the processes that generated to by-product will be added to the processes that use the by-product. When the bark is used to generate energy, it also receives a credit. A credit is received because, energy is generated from a by-product of the manufacturing process, which would have otherwise come from other outside fuel sources, such as purchasing natural gas or other hog fuel.

Comparing the characterizations between the fuel sources, one trend is recognized in both plywood and LVL manufacturing. The debarking and bucking machine center credit in the natural gas scenarios makes up almost 70% of the total Ecotoxicity damage category. This indicates that the majority of the emissions from hog fuel (or bark) source are classified in the Ecotoxicity damage category and are produced at higher levels than natural gas. These air emissions include arsenic, benzene, chromium, nickel, lead, and zinc (see Appendix F,G).

The final scores of the impact assessment are presented in Table 18, Figure 15, and Figure 16. Similar to the drying machine center analysis, Climate Change, Respiratory Inorganic, and Fossil Fuels make up 93-97% of the total score (environmental impact). Furthermore, Fossil Fuels damage category makes up 63-71% the total.

Switching to hog fuel as the heating fuel source increases the impact caused by the damage categories Climate Change and Ecotoxicity. The impact caused by damage categories Carcinogens, Respiratory Organic, Respiratory Inorganic, Acid/Eutrophication, and Fossil Fuels decreased when using 100% hog fuel. Once again the opposite is true when using natural gas as a heating fuel source; Climate Change and Ecotoxicity damage categories decrease and Carcinogens, Respiratory Organic, Respiratory Inorganic, Acid/Eutrophication, and Fossil Fuels damage categories increase.

Table 18: Comparing the environmental impact scores of the plywood and LVL manufacturing processes with different heating fuel sources in the PNW region.

	Plywood		
	100% Hog Fuel (Point/Msm 9-mm basis)	100% Natural Gas (Point/Msm 9-mm basis)	Industry Practice (Point/Msm 9-mm basis)
Carcinogens	1.229	4.434	1.957
Respiratory Organic	0.644	0.910	0.711
Respiratory Inorganic	17.992	66.386	29.143
Climate Change	19.286	11.374	17.339
Radiation	0.721	0.721	0.721
Ozone Layer	2.328	-0.156	1.776
Ecotoxicity	2.504	6.072	3.327
Acid/Eutrophication	77.132	198.285	107.678
Land-Use	–	–	–
Minerals	–	–	–
Fossil Fuels	121.836	288.027	162.651
Total			
	LVL		
	100% Hog Fuel ($Point/m^3$)	100% Natural Gas ($Point/m^3$)	Industry Practice ($Point/m^3$)
Carcinogens	1.658	5.191	2.469
Respiratory Organic	0.741	1.035	0.813
Respiratory Inorganic	22.778	75.969	35.134
Climate Change	22.379	13.626	20.199
Radiation	–	–	–
Ozone Layer	0.802	0.803	0.803
Ecotoxicity	2.573	-0.160	1.966
Acid/Eutrophication	2.863	6.792	3.781
Land-Use	–	–	–
Minerals	–	–	–
Fossil Fuels	115.191	247.948	149.054
Total	168.985	351.203	214.220

Figure 15. Comparing the base case environmental impact scores for the different fuel sources by machine center for Msm 9-mm plywood in the PNW.

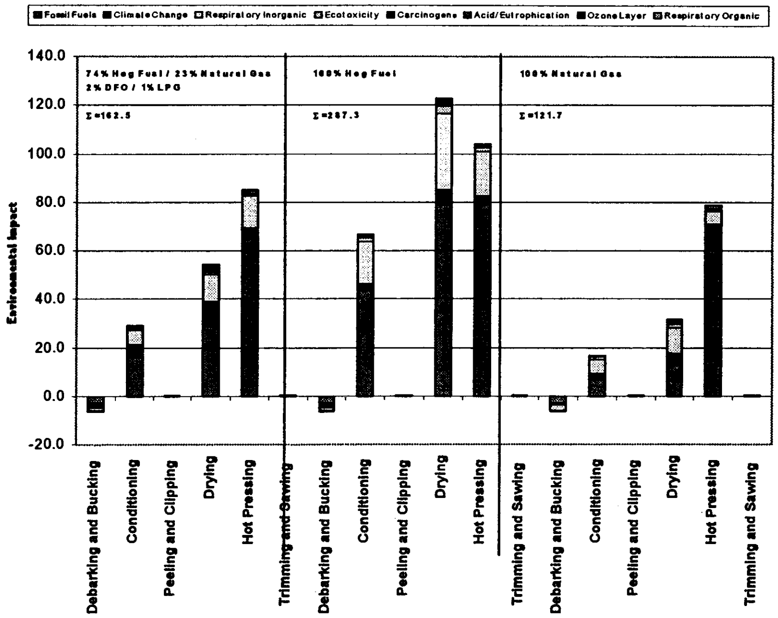
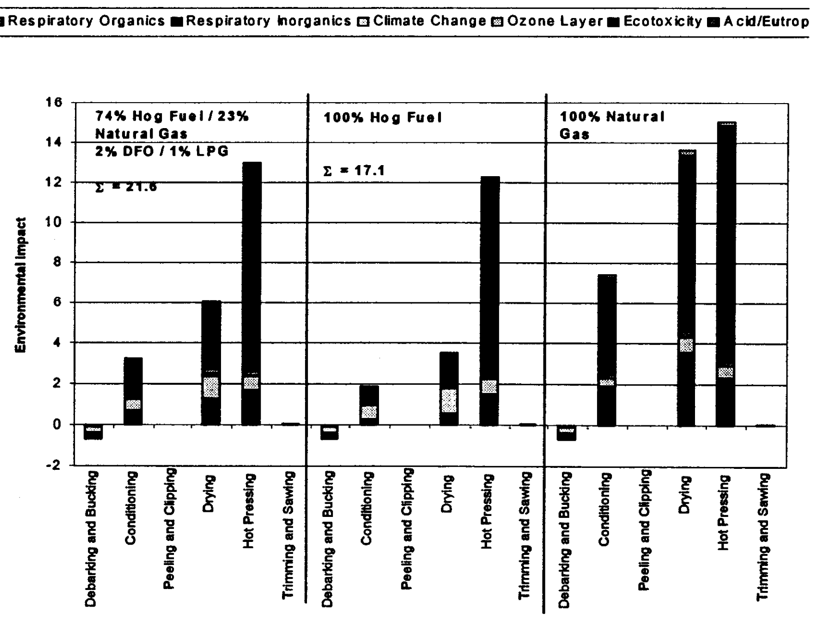


Figure 16. Comparing the base environmental impact scores for the different fuel soucrces by machine center for m^3 of LVL in the PNW.



These "trade offs" between fuel sources directly relate to the air and water emissions created and raw materials used to generate the selected fuel source. Climate Change damage category is greater when using hog fuel because of higher CO_2 emissions generated during combustion compared to natural gas. Likewise for the Ecotoxicity damage category, utilizing hog fuel increases the rate of arsenic, benzene, chromium, nickel, lead, and zinc air emissions compared to natural gas. Carcinogens damage category is greater when using natural gas because of the increase in air emissions of cadmium, dichloromethane, and metals, and water emissions of cadmium and chromium compared to hog fuel. When using natural gas, aldehydes, methane, and non-methane VOCs increase, resulting in a higher Respiratory Organic damage category compared to hog fuel. Respiratory Inorganic and Acid/Eutrophication damage categories are greater when using natural gas because of the higher rate of NO_X and SO_X air emissions compared to hog fuel. Finally, Fossil Fuels damage category is greater when using natural gas because of the natural gas consumption compared to hog fuel.

Figures 15 and 16 display the impact assessment results by machine center. Fossil Fuels have the greatest impact on the plywood and LVL processes. The greatest portion of the environmental scores come from the conditioning, drying, and hot pressing machine centers for all six scenarios. This relates to all the emissions generated during the manufacturing processes and the energy required (both heating and electricity). The energy consumption, heating in particular, has the greatest overall effect on the impact assessment. The hot pressing machine center is the highest for both plywood and LVL processes with the industry practice and 100% hog fuel heating sources, even though the drying machine center consumes more energy through electricity and heating. This relates to the phenol-formaldehyde used. Phenol-formaldehyde is manufactured from natural gas and crude oil. The drying machine center has the greatest impact when switching the heating fuel source to natural gas. This increase is attributed to uses of natural gas, a fossil fuel, as a heating fuel source.

SOUTHERN PLYWOOD AND LVL PROCESSES

The heating fuel source is analyzed for the southern plywood and LVL mills. As with the PNW, 100% hog fuel, 100% natural gas, and the southern region "industry Practice" are examined. Table 19 compares the emissions for both manufacturing processes with the three heating fuel sources. Figures 17 and 18 show the natural log trends of these emissions when switching to hog fuel or natural gas. Switching to 100% hog fuel compared to the industry practice and 100% natural gas scenarios increase the emissions rate for CO, CO_2, and solid waste while decreasing the rate SO_X, NO_X, N_2O, methane, BOD, suspended and dissolved solids are produced.

These trends are related to the emissions generated while producing the energy from the selected heating fuel source (see Appendix G).

Beginning the impact assessment, the characterization step displays the machine centers pre-normalized and pre-weighted amount percentages of each damage category. Figures 19 and 20 display the results of the characterization step for the

Table 19: Comparing the quantitative emissions for the plywood and LVL manufacturing with different fuel sources for heating in the southern region.

	Plywood		
	100% Hog Fuel (kg/Msm 9-mm basis)	100% Natural Gas (kg/Msm 9-mm basis)	Industry Practice (kg/Msm 9-mm basis)
Air Emissions:			
CO	2.79 E+01	5.61 E+00	1.67 E+01
CO_2	5.18 E+03	3.33 E+03	4.26 E+03
N_2O	6.91 E-03	7.15 E-03	7.03 E-03
NO_x	8.62 E+00	1.16 E+01	1.01 E+01
SO_x	1.06 E+01	4.59 E+01	2.77 E+01
Methane	2.80 E+00	9.45 E+00	6.02 E+00
Particulates	1.25 E+01	1.24 E+01	1.25 E+01
Water Emissions:			
BOD	7.68 E-03	5.91 E-02	3.30 E-02
Dissolved Solids	8.27 E+00	6.20 E+01	3.42 E+01
Suspended Solids	5.55 E-01	1.51 E+00	1.02 E+00
Land Emissions:			
Solid Waste	3.40 E+02	2.56 E+01	2.97 E+02
	LVL		
	100% Hog Fuel (kg/m^3)	100% Natural Gas (kg/m^3)	Industry Practice (kg/m^3)
Air Emissions:			
CO	3.13 E+00	6.71 E-01	1.89 E+00
CO_2	5.41 E+02	3.38 E+02	4.41 E+02
N_2O	2.96 E-04	3.19 E-04	3.07 E-04
NO_x	8.39 E-01	1.17 E+00	1.00 E+00
SO_x	1.14 E+00	5.02 E+00	3.02 E+00
Methane	2.52 E-01	9.79 E-01	6.06 E-01
Particulates	1.33 E+00	1.32 E+00	1.33 E+00
Water Emissions:			
BOD	1.23 E-03	6.91 E-03	4.00 E-03
Suspended Solids	2.62 E-02	1.31 E-01	7.71 E-02
Dissolved Solids	1.33 E+00	7.18 E+00	4.17 E+00
Land Emissions:			
Solid Waste	2.84 E+01	1.92 E+01	2.36 E+01

Figure 17. Comparing the natural log of the quantitative emissions for different heating fuel sources when manufacturing Msm plywood in the southern region.

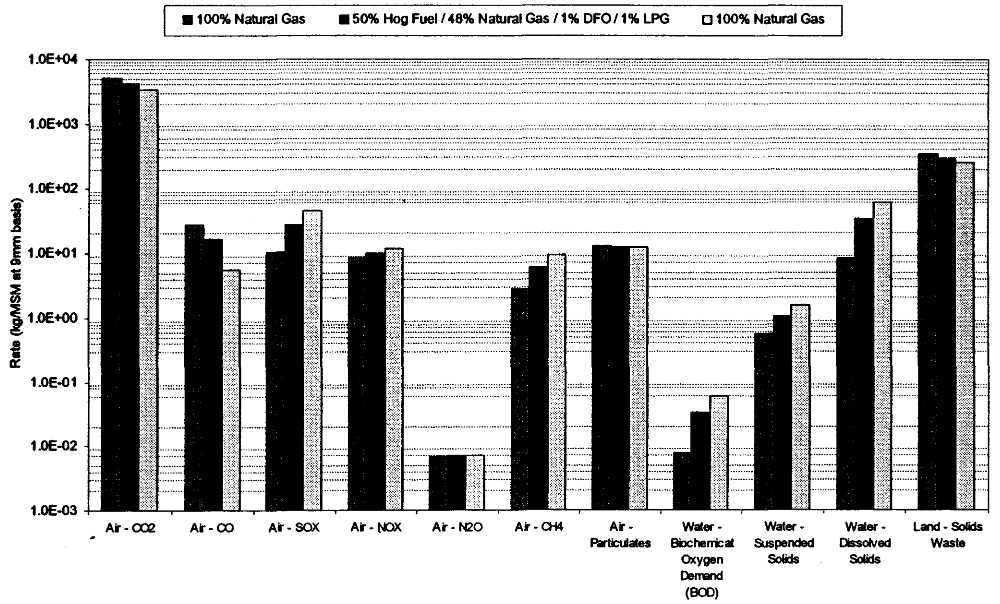
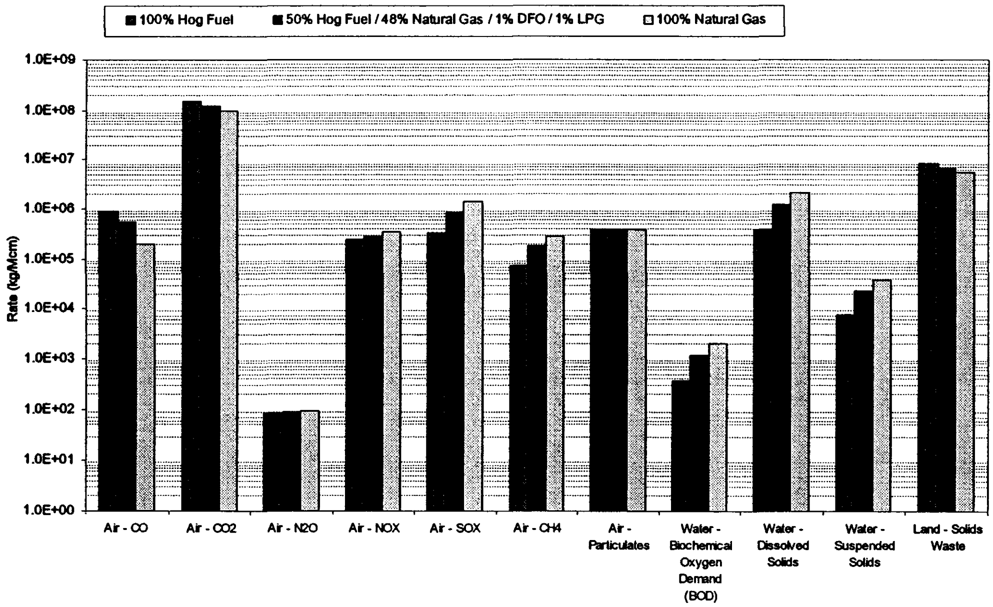


Figure 18. Comparing the quantitative emissions for different heating fuel sources when manufacturing m^3 LVL in the southern regions.



plywood and LVL processes and the different heating fuel sources. The characterization step reveals that the majority of the classified amounts are associated with the conditioning, drying, and hot pressing machine centers. Whereas the trimming and sawing machine center contribute a good portion to the Ozone Layer damage category. These distributions relate to the electricity and heat consumption of the four machine centers, comprising 100% of the heat and 71% of the electricity consumption (See Appendix E). The debarking and bucking machine center serves as a significant credit to the Climate Change and Ecotoxicity damage categories. Utilizing the bark residue as a heating fuel source generates this credit.

The trend of the debarking and bucking machine center contributing a credit of approximately 40% to the Ecotoxicity damage category, as seen in the PNW analysis, is present. Once again, the majority of emissions from the hog fuel source are classified in the ecotoxicity damage category and are produced at higher levels than natural gas. These air emissions include arsenic, benzene, chromium, nickel, lead, and zinc (see Appendix F,G).

The final scores of the impact assessment are presented in Table 20, Figure 21, and 22. Approximately 95% of the total score for the six scenarios is comprised from the Respiratory Organic, Climate Change, and Fossil Fuels damage categories. Fossil Fuel damage category contributes 56-65% of the total score. The discussion for the southern plywood and LVL heating fuel source comparison are consistent with those discussed during the PNW plywood and LVL processes discussion.

Figure 19. Characterization of the damage categories for the different heating fuel sources by machine center for Msm 9-mm basis plywood in the southern region.

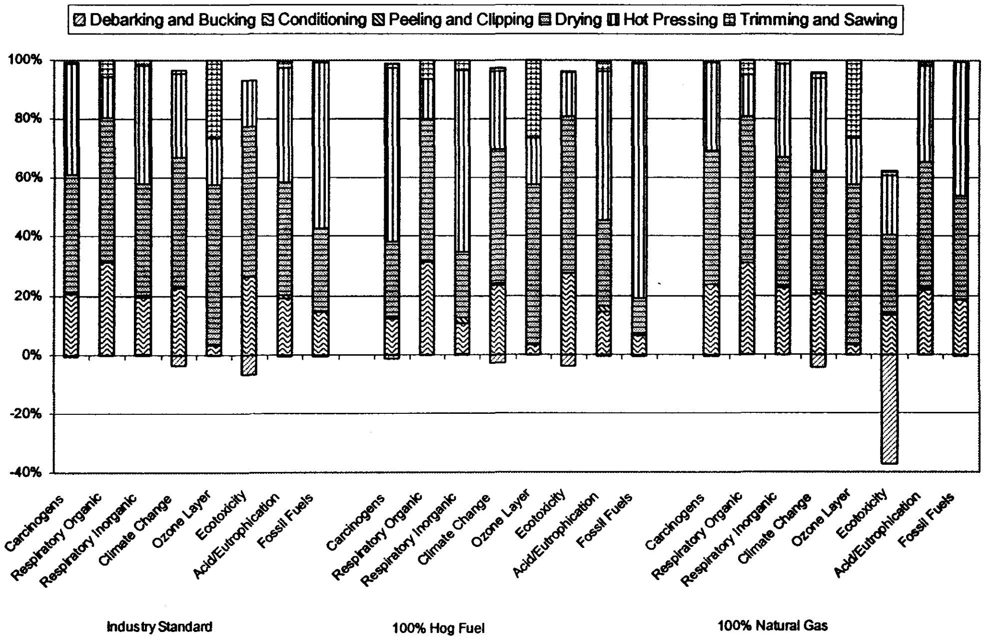


Figure 20. Characterization of the damage categories for the different heating fuel sources by machine center for m^3 LVL in the southern region.

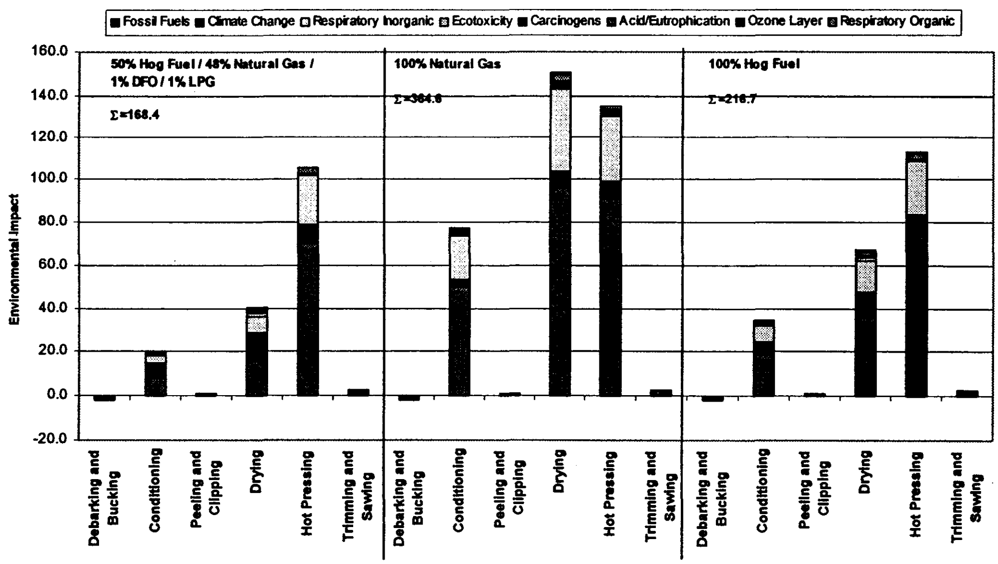


Table 20: Comparing the environmental impact scores of the plywood and LVL manufacturing processes with different heating fuel sources in the southern region.

	Plywood		
	100% Hog Fuel (Point/Msm 9-mm basis)	100% Natural Gas (Point/Msm 9-mm basis)	Industry Practice (Point/Msm 9-mm basis)
Carcinogens	0.245	2.833	1.140
Respiratory Organic	0.147	0.232	0.187
Respiratory Inorganic	119.676	830.914	385.171
Climate Change	80.342	36.379	56.224
Radiation	–	–	–
Ozone Layer	0.013	0.013	0.013
Ecotoxicity	0.903	0.001	0.270
Acid/Eutrophication	2.162	7.789	4.457
Land-Use	871.686	5540.386	2689.347
Minerals	–	–	–
Fossil Fuels	–	–	–
Total	1075.173	6418.547	3136.810

	LVL		
	100% Hog Fuel (Point/m^3)	100% Natural Gas (Point/m^3)	Industry Practice (Point/m^3)
Carcinogens	0.208	0.625	0.409
Respiratory Organic	0.139	0.172	0.155
Respiratory Inorganic	3.558	9.837	6.604
Climate Change	2.993	1.961	2.482
Radiation	–	–	–
Ozone Layer	0.041	0.041	0.041
Ecotoxicity	0.332	0.009	0.181
Acid/Eutrophication	0.467	0.931	0.692
Land-Use	–	–	–
Minerals	–	–	–
Fossil Fuels	13.777	29.527	21.605
Total	21.516	43.102	32.169

Figure 21. Comparing environmental impact score for the different heating fuel sources by machine center for m^3 of LVL in the southern region.

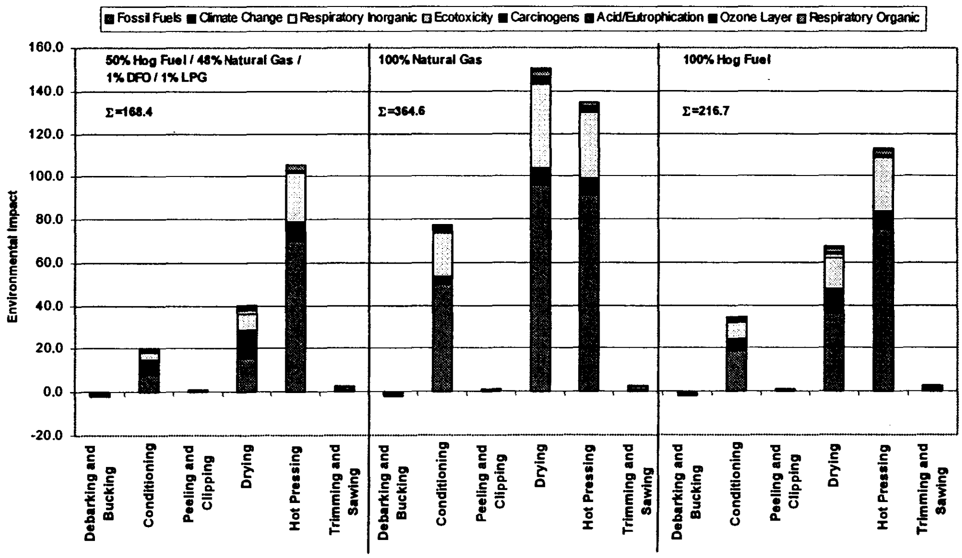
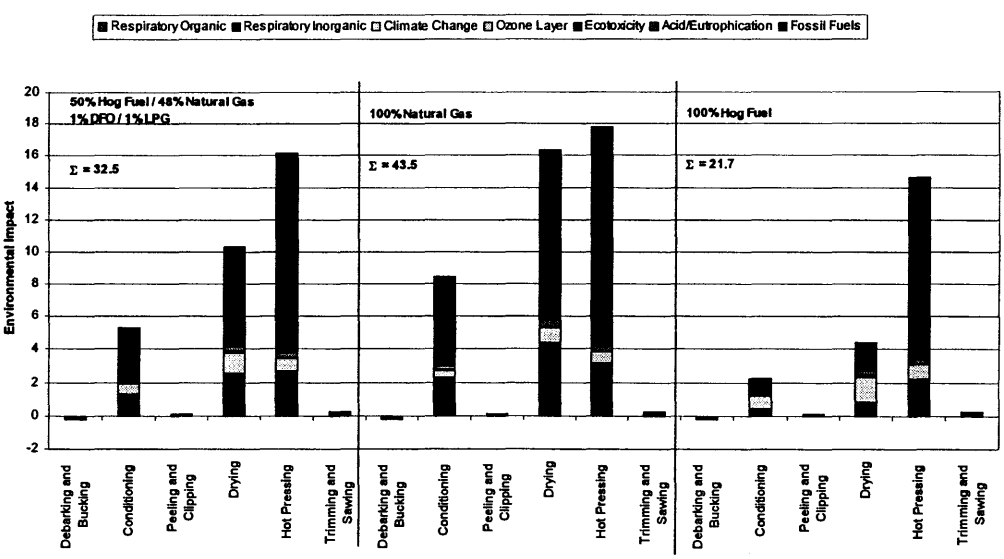


Figure 22. Comparing environmental impact scores for the different heating fuel sources by machine center for m^3 of LVL in the southern region.



PACIFIC NORTHWEST VERSUS SOUTHERN REGION

The magnitude of emissions and scores for the base cases are higher for the southern region plywood and LVL plants when compared to the Pacific Northwest. These differences are attributed to four areas: heat consumption, heating fuel source distribution, electricity generation, and resin usage.

Heat consumption in the Southern region is 15% greater compared to the PNW. The way the heat is generated also makes a difference. The Southern region utilizes a greater percentage of natural gas (48%) compared to the PNW (23%). In this study, natural gas consumption, when compared to hog fuel, contributes to the increase in the majority of the measured emissions, subsequently increasing the impact scores.

As with heat generation, electricity generation plays an important role on the outcome of the inventory analysis and impact assessment. In the PNW, 89.5% of electricity generation is from hydro-electric power (see Table 5) (Energy Information Administration, 1999). In the Southern region, electricity is generated from coal (54.7%), nuclear power (27.5%), and naturel gas (11.7%) (see Table 6) (Energy Information Administration, 1999) . Hydro-electric energy is a clean energy source. There are no emissions generated when converting moving water into energy. On the other hand, fossil fuels create air, water, and land emissions when combusted. Essentially, 89.5% of the generated electricity in the PNW is clean energy, while 93.9% of electricity generated in the southern region is from fossil fuels (66.4%) and nuclear power (or uranium) (27.5%).

CO_2 air emissions are related to electricity, as well as heat consumption and generation. The results for drying machine center scenarios without pollution control devices exhibits similar CO_2 emissions when comparing the PNW to the southern region. The plywood drying machine centers were examined to explain the similarities. The southern region uses less electricity (967 MJ) in comparison to the PNW (1374 MJ), but the southern region uses more heat (22,253 MJ) than the PNW (19,332 MJ). From the electricity standpoint, the PNW would generate the least amount of CO_2 because of the large portion of hydro-electric generation compared to the southern region. In terms of heat generation, the PNW generates the most because of the larger portion of hog fuel used in comparison to the southern region.

Finally, resin usage contributes to the differences in magnitude of the inventory analysis and impact assessment for the PNW and Southern region. Phenol-formaldehyde is created through the refining of natural gas and petroleum. According to Koch, Southern Yellow Pine laminates require more resin than do Douglas-fir because of the greater veneer roughness of the Southern Yellow Pine (Koch, 1972b).

CONCLUSIONS

Successful LCI and LCA models were created for analyzing emissions and the environmental impact of LVL and plywood manufacturing in the Pacific Northwest and southern regions of the United States. More specifically, these models were able to display the effect input changes had on the emissions and environmental impact assessment. These models were created in the SimaPro software and will be updated as new data become available.

Breaking down the manufacturing processes into six machine centers: debarking and bucking, conditioning, peeling and clipping, drying, hot pressing, and trimming and sawing, proved to be insightful. Distributing the total inputs, which affects the outputs, across the six machine centers enables interested parties to pinpoint desired inquires (i.e., energy consumption or a particular emission).

Three machine centers had the greatest effect on the environment for the plywood and LVL base cases in both regions (in increasing order): conditioning, drying and hot pressing. These machine centers contributed the most because of the large amounts of energy required for heating. The hot pressing machine center had the greatest environment impact because of the energy consumption and resin usage. This impact is most evident in the Fossil Fuel, Climate Change, and Respiratory Inorganic damage categories.

Utilizing the bark generated during debarking and bucking as a fuel source proves to be beneficial to the environment. Using the bark reduces the burden of using fossil fuels for energy and all emissions associated with generating the energy. For these manufacturing processes, energy consumption is the key parameter when attempting to reduce the environmental impact.

Of the three energy sources for heating, hog fuel had the least impact on the environment, while natural gas had the greatest. Utilizing hog fuel for energy is extremely beneficial when trying to reduce the burden on fossil fuels, which are used for energy. Hog fuel is readily available, a manufacturing by-product, and renewable. Hydroelectric power is the best alternative for generating electricity in-terms of emissions compared to that generated with natural gas, petroleum, coal and nuclear power. There is no air, water, or land emissions generated during the hydroelectric process.

From the sensitivity analysis on the drying machine center and its pollution control devices, it was concluded pollution control devices–Wet Electrostatic Precipitators, Regenerative Thermal Oxidizers, and Regenerative Catalytic Oxidizers–increase the environmental impact of the machine center. The devices did reduce certain air emissions at the dryer. However, the emissions produced during the generation of the energy required to operate the pollution control devices outweighs these reductions.

All data reported in the main text are in accordance with the CORRIM II research guidelines. Extensive Appendices provide CORRIM II with the complete amount of data generated during this research. As more comprehensive and current input and output data is gathered, this model can provide CORRIM II with up-to-date information on the plywood and LVL processes in the Pacific Northwest and southern regions.

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APPENDICES

APPENDIX A

Calculations for packaging MSF 3/8" basis of Douglas-fir (DF) plywood:
Assumptions:

Band used: Steel
Band size: 2.54 cm x 318 cm
Number of bands: 2
Band weight rate: 1.02 g/cm length of band 2.54 cm wide
Stickers used: DF
Number of stickers: 2
Dimensions of stickers: 121.92 cm x 8.89 cm x 3.81 cm
Weight of sticker (oven-dry): 1.81 kg

Weight calculations for steel bands:

2 x 318 cm = 636 cm of steel bands

(636 cm) x (1.02 g/cm length of band 2.54 cm wide) = 648.72 g of steel band

Weight calculations for DF stickers:

2 x 1.81 kg = 3.62 kg of oven-dry DF stickers

Weight Percentage of final product:

(0.64872 kg of steel bands) / [(471 kg for MSF 3/8" basis DF plywood) + (3.62 kg of oven-dry DF stickers) + (0.64872 kg of steel band)] x 100 =

= 0.14 % of the total product weight for steel bands

(3.62 kg of oven-dry DF stickers) / [(471 kg for MSF 3/8" basis DF plywood) + (3.62 kg of oven-dry DF stickers) + (0.64872 kg of steel bands)] x 100 =

= 0.76 % of the total product weight for DF stickers

<u>Calculations for heat generated from burning bark in a boiler</u>:

Assumptions:

oven-dry bark from manufacturing MSF (3/8" basis) of plywood in the PNW:
161 kg or 355 lbs. (see Figure 2.3)

oven-dry bark from manufacturing MCF of LVL in the PNW:
5,153 kg or 11,362 lbs. (see Figure 2.4)

oven-dry bark from manufacturing MSF (3/8" basis) of plywood in the south:
68 kg or 150 lbs. (see Figure 2.5)

oven-dry bark from manufacturing MCF of LVL in the south:
2,191 kg or 4,831 lbs. (see Figure 2.5)

heat of formation assuming a 50% moisture content:
2,165 BTU / lb dry wood (Kirk and Wilson, 1983)

efficiency of heat recovery:
50%

Heat from bark produced from manufacturing MSF (3/8" basis) of plywood in the PNW:

335 lbs. * 2,165 BTU / lb dry wood = 768,575 BTUs

768,575 BTUs * 1.055 E-3 MJ / BTU = 811 MJ

811 MJ * 50% efficiency = 406 MJ

Heat from bark produced from manufacturing MCF of LVL in the PNW:

11,362 lbs. * 2,165 BTU / lb dry wood = 24,598,730 BTUs

24,598,730 BTUs * 1.055 E-3 MJ / BTU = 25,952 MJ

25,952 MJ * 50% efficiency = 12,976 MJ

Heat from bark produced from manufacturing MSF (3/8" basis) of plywood in the south:

150 lbs. * 2,165 BTU / lb dry wood = 324,750 BTUs

324,750 BTUs * 1.055 E-3 MJ / BTU = 343 MJ

343MJ * 50% efficiency = 172 MJ

Heat from bark produced from manufacturing MCF of LVL in the south:

4,831 lbs. * 2,165 BTU / lb dry wood = 10,459,115 BTUs

10,459,115 BTUs * 1.055 E-3 MJ / BTU = 11,034 MJ

11,034 MJ * 50% efficiency = 5,517 MJ

APPENDIX B

Description:
Region: Pacific Northwest
Species: Douglas-fir
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768.

LOG CONDITIONING EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.3901	12.4828
alkenes	44.5425	1425.3612
aromatic	8.3461	267.0738
organic w/ chlorine	0.2631	8.4186
xylene	0.1724	5.5157
Specifc emissions		
methyl bromide	0.1542	4.9351
acetaldehyde	2.1319	68.2199
acrolein	0.3447	11.0313
benzene	0.1270	4.0642
vinyl chloride	0.1043	3.3384
formaldehyde	0.1043	3.3384
dichloromethane	0.1406	4.4996
phenol	0.6804	21.7723
methanol	3.3112	105.9586
acetone	1.3608	43.5446
methyl ethyl ketone	0.4354	13.9343
methyl I-butyl ketone	0.4173	13.3537
styrene	0.1724	5.5157
toluene	0.1497	4.7899
o-xylene	0.1724	5.5157
1,2-dichloroethane	0.1633	5.2254
1,2,4-trichlorobenzene	0.2994	9.5798

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: Log Conditioning Data for the Northwest from NCASI technical bulletin 768 was adjusted with the ratio of southeast/northwest dryer emissions.

LOG CONDITIONING EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.1854	5.9331
alkenes	699.8021	22,393.6671
aromatic	3.5511	113.6362
organic w/ chlorine	0.1117	3.5743
xylene	0.2646	8.4661
Specifc emissions		
methyl bromide	0.0662	2.1182
acetaldehyde	1.2732	40.7414
acrolein	1.2257	39.2224
benzene	0.1219	3.9016
vinyl chloride	0.0443	1.4184
formaldehyde	0.0418	1.3388
dichloromethane	0.0597	1.9091
phenol	0.3606	11.5398
methanol	3.4163	109.3201
acetone	1.2313	39.4008
methyl ethyl ketone	0.1836	5.8737
methyl I-butyl ketone	0.1782	5.7018
styrene	0.0729	2.3336
toluene	0.0411	1.3144
o-xylene	0.0737	2.3577
1,2-dichloroethane	0.0688	2.2017
1,2,4-trichlorobenzene	0.1290	4.1272

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest
Species: Douglas-fir
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

DRYER EMISSIONS FROM INDIRECT STEAM HEAT

Groupings	g/MSF 3/8" basis	g/MCF
aldehydes	1.5842	50.6932
alkenes	133.8204	4282.2525
aromatic	40.9365	1309.9679
organic w/ chlorine	0.7841	25.0926
xylene	0.2370	7.5840
Specific emissions		
methyl bromide	0.7609	24.3487
acetaldehyde	10.6333	340.2651
acrolein	0.0561	1.7962
benzene	0.2778	8.8904
vinyl chloride	0.5018	16.0571
formaldehyde	11.0619	353.9816
dichloromethane	0.6821	21.8268
phenol	1.1878	38.0108
methanol	16.4426	526.1644
acetone	7.2688	232.6010
methyl ethyl ketone	2.0015	64.0469
methyl I-butyl ketone	1.9334	61.8697
styrene	0.8448	27.0340
toluene	1.1340	36.2872
o-xylene	0.8510	27.2335
1,2-dichloroethane	0.7966	25.4918
1,2,4-trichlorobenzene	1.4572	46.6291

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest
Species: Douglas-fir
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: All data from NCASI TB 768, VOC data for TB 694 was distributed and averaged as a percentage of the specific compounds for TB 768. Averaging was based on the number of mills the data came from.

DRYER W/ WESP EMISSIONS: INLET INDIRECT STEAM HEAT

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	1.4968	47.8991
alkenes	158.5388	5073.2409
aromatic	37.9201	1213.4440
organic w/ chlorine	2.5129	80.4124
xylene	0.7892	25.2559
Specific emissions		
methyl bromide	0.7076	22.6432
acetaldehyde	10.6231	339.9385
acrolein	1.4333	45.8670
benzene	0.5851	18.7242
vinyl chloride	1.7509	56.0274
formaldehyde	5.1256	164.0181
dichloromethane	0.6260	20.0305
phenol	2.9211	93.4758
methanol	17.0550	545.7595
acetone	3.2749	104.7974
methyl ethyl ketone	1.8053	57.7692
methyl I-butyl ketone	1.4968	47.8991
styrene	0.7802	24.9656
toluene	0.6895	22.0626
o-xylene	0.7892	25.2559
1,2-dichloroethane	0.7439	23.8044
1,2,4-trichlorobenzene	1.3517	43.2543
PM	53.6345	1716.3039

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: All data from NCASI technical bulletin (TB) 768, except, CO and PM data from NCASI TB 694. VOC data for TB 694 was distributed and averaged as a percentage of the specific compounds for TB 768. Averaging was based on the number of mills the data came from.

DRYER EMISSIONS FROM INDIRECT STEAM HEAT

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	1.3433	42.9865
alkenes	1585.6063	50739.4014
aromatic	31.0884	994.8300
organic w/ chlorine	0.9816	31.4108
xylene	0.6467	20.6949
Specific emissions		
methyl bromide	0.5786	18.5149
acetaldehyde	10.1709	325.4691
acrolein	1.3932	44.5831
benzene	0.4750	15.1988
vinyl chloride	0.3781	12.0976
formaldehyde	7.0813	226.6002
dichloromethane	0.5133	16.4270
phenol	1.6734	53.5489
methanol	29.7451	951.8435
acetone	11.0789	354.5259
methyl ethyl ketone	1.4969	47.8992
methyl I-butyl ketone	1.4777	47.2851
styrene	0.6342	20.2958
toluene	0.5565	17.8087
o-xylene	0.6467	20.6949
1,2-dichloroethane	0.5968	19.0983
1,2,4-trichlorobenzene	1.0958	35.0647
Methane	4.3732	139.9416
Ethane	1.0206	32.6585
CO	12.7941	409.4103
PM	533.8273	17082.4743

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: All data from NCASI technical bulletin (TB) 768, except, CO, NOx and PM data from NCASI technical bulletin 694. VOC data for TB 694 was distributed and averaged as a percentage of the specific compounds for TB 768. Averaging was based on the number of mills the data came from.

DRYER EMISSIONS FROM DIRECT HEAT (NATURAL GAS)

Groupings	g/MSF 3/8" basis	g/MCF
aldehydes	0.9516	30.4496
alkenes	643.2479	20583.9317
aromatic	22.3614	715.5657
organic w/ chlorine	0.7137	22.8372
xylene	1.8079	57.8542
Specific emissions		
methyl bromide	0.4187	13.3978
acetaldehyde	18.0795	578.5425
acrolein	5.7093	182.6976
benzene	3.7110	118.7535
vinyl chloride	0.2759	8.8304
formaldehyde	41.3924	1324.5577
dichloromethane	0.3759	12.0276
phenol	1.3797	44.1519
methanol	17.1279	548.0929
acetone	27.2154	870.8928
methyl ethyl ketone	1.0467	33.4946
methyl I-butyl ketone	1.4749	47.1969
styrene	0.5709	18.2698
toluene	4.3771	140.0682
o-xylene	0.4710	15.0726
1,2-dichloroethane	0.4377	14.0068
1,2,4-trichlorobenzene	0.8088	25.8822
Methane	54.6576	1749.0430
Ethane	2.0412	65.3170
CO	243.0486	7777.5565
NOx	5.5338	177.0815
PM	224.3003	7177.6082

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

DRYER W/ RTO EMISSIONS: INLET INDIRECT STEAM HEAT

Groupings	g/MSF 3/8" basis	g/MCF
aldehydes	0.8845	28.3040
alkenes	62.3686	1995.7960
aromatic	19.2776	616.8824
organic w/ chlorine	0.6033	19.3048
xylene	0.3901	12.4828
Specific emissions		
methyl bromide	0.3561	11.3942
acetaldehyde	0.6123	19.5951
acrolein	0.7802	24.9656
benzene	0.0635	2.0321
vinyl chloride	0.2359	7.5477
formaldehyde	1.0047	32.1505
dichloromethane	0.3220	10.3056
phenol	1.8144	58.0595
methanol	0.8391	26.8525
acetone	0.5216	16.6921
methyl ethyl ketone	0.9752	31.2070
methyl I-butyl ketone	0.9525	30.4812
styrene	0.3878	12.4102
toluene	0.3515	11.2490
o-xylene	0.3901	12.4828
1,2-dichloroethane	0.3833	12.2651
1,2,4-trichlorobenzene	0.6781	21.6997
Methane	14.9760	479.2330
CO	27.5632	882.0209

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

DRYER EMISSIONS W/ RCO: INLET INDIRECT STEAM HEAT AND DIRECT(GAS) HEAT

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	1.3608	43.5446
alkenes	100.6970	3222.3034
aromatic	31.7513	1016.0416
organic w/ chlorine	0.9888	31.6424
xylene	0.6350	20.3208
Specific emissions		
methyl bromide	0.5897	18.8693
acetaldehyde	27.6690	885.4077
acrolein	1.1793	37.7387
benzene	0.4989	15.9664
vinyl chloride	0.3856	12.3376
formaldehyde	17.2364	551.5654
dichloromethane	0.5443	17.4179
phenol	2.4947	79.8318
methanol	2.2226	71.1229
acetone	21.7723	696.7142
methyl ethyl ketone	1.4968	47.8991
methyl I-butyl ketone	1.4515	46.4476
styrene	0.6350	20.3208
toluene	0.5897	18.8693
o-xylene	0.6350	20.3208
1,2-dichloroethane	0.5897	18.8693
1,2,4-trichlorobenzene	1.1340	36.2872
Methane	44.1494	1412.7817
Ethane	4.0823	130.6339
CO	4.6871	149.9871

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest
Species: Douglas-fir
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

VENEER REDRY EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.1225	3.9190
alkenes	11.7933	377.3869
aromatic	2.4947	79.8318
organic w/ chlorine	0.0821	2.6272
xylene	0.0544	1.7418
Specific emissions		
methyl bromide	0.0454	1.4515
acetaldehyde	0.1225	3.9190
acrolein	0.1089	3.4836
benzene	0.0390	1.2483
vinyl chloride	0.0313	1.0015
formaldehyde	0.0340	1.0886
dichloromethane	0.0422	1.3499
phenol	0.2223	7.1123
methanol	0.2359	7.5477
acetone	0.1814	5.8060
methyl ethyl ketone	0.1361	4.3545
methyl I-butyl ketone	0.1315	4.2093
styrene	0.0499	1.5966
toluene	0.0454	1.4515
o-xylene	0.0544	1.7418
1,2-dichloroethane	0.0499	1.5966
1,2,4-trichlorobenzene	0.0907	2.9030

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

VENEER REDRY EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.3493	11.1765
alkenes	213.0512	6817.6391
aromatic	7.3935	236.5925
organic w/ chlorine	0.2359	7.5477
xylene	0.1542	4.9351
Specific emissions		
methyl bromide	0.1361	4.3545
acetaldehyde	1.3154	42.0932
acrolein	0.3084	9.8701
benzene	0.1134	3.6287
vinyl chloride	0.0907	2.9030
formaldehyde	0.2948	9.4347
dichloromethane	0.1225	3.9190
phenol	0.6350	20.3208
methanol	2.1772	69.6714
acetone	0.6350	20.3208
methyl ethyl ketone	0.3901	12.4828
methyl I-butyl ketone	0.3719	11.9022
styrene	0.1497	4.7899
toluene	0.1315	4.2093
o-xylene	0.1542	4.9351
1,2-dichloroethane	0.1451	4.6448
1,2,4-trichlorobenzene	0.2631	8.4186

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest
Species: Douglas-fir
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

VENEER COOLING EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	3.8404	122.8927
alkenes	302.0909	9666.9101
aromatic	94.9515	3038.4482
organic w/ chlorine	2.9937	95.7982
xylene	0.4385	14.0311
Specific emissions		
methyl bromide	1.7690	56.6080
acetaldehyde	1.6601	53.1245
acrolein	3.3414	106.9263
benzene	1.4515	46.4476
vinyl chloride	1.1642	37.2549
formaldehyde	0.9586	30.6748
dichloromethane	1.5876	50.8021
phenol	0.1512	4.8383
methanol	2.3284	74.5097
acetone	5.0348	161.1152
methyl ethyl ketone	4.3242	138.3752
methyl I-butyl ketone	2.4191	77.4127
styrene	1.9353	61.9302
toluene	1.7085	54.6727
o-xylene	0.2722	8.7089
1,2-dichloroethane	1.8597	59.5110
1,2,4-trichlorobenzene	3.4019	108.8616

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

VENEER COOLING EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.9516	30.4496
alkenes	643.2479	20583.9317
aromatic	22.3614	715.5657
organic w/ chlorine	0.7137	22.8372
xylene	1.8079	57.8542
Specific emissions		
methyl bromide	0.4187	13.3978
acetaldehyde	18.0795	578.5425
acrolein	5.7093	182.6976
benzene	3.7110	118.7535
vinyl chloride	0.2759	8.8304
formaldehyde	41.3924	1324.5577
dichloromethane	0.3759	12.0276
phenol	1.3797	44.1519
methanol	17.1279	548.0929
acetone	27.2154	870.8928
methyl ethyl ketone	1.0467	33.4946
methyl I-butyl ketone	1.4749	47.1969
styrene	0.5709	18.2698
toluene	4.3771	140.0682
o-xylene	0.4710	15.0726
1,2-dichloroethane	0.4377	14.0068
1,2,4-trichlorobenzene	0.8088	25.8822

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest and Southern
Species: Douglas-fir and Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: NCASI technical bulletin 768

DRY CHIP CYCLONE EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.4989	15.9664
alkenes	46.2662	1480.5178
aromatic	11.7933	377.3869
organic w/ chlorine	0.3765	12.0474
xylene	0.2495	7.9832
Specific emissions		
methyl bromide	0.2223	7.1123
acetaldehyde	0.1950	6.2414
acrolein	0.4536	14.5149
benzene	0.1860	5.9511
vinyl chloride	0.1451	4.6448
formaldehyde	0.1089	3.4836
dichloromethane	0.1996	6.3865
phenol	0.6804	21.7723
methanol	3.9462	126.2795
acetone	0.1950	6.2414
methyl ethyl ketone	0.5897	18.8693
methyl I-butyl ketone	0.5443	17.4179
styrene	0.2449	7.8380
toluene	0.2177	6.9671
o-xylene	0.2495	7.9832
1,2-dichloroethane	0.2313	7.4026
1,2,4-trichlorobenzene	0.4264	13.6440
PM	5.4115	173.1669

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest
Species: Douglas-fir
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: All data from NCASI technical bulletin 768.

HOT PRESS EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	1.5422	49.35059
alkenes	106.1401	3396.48192
aromatic	33.3389	1066.84368
organic w/ chlorine	3.7149	118.87687
xylene	0.6963	22.28034
Specific emissions		
methyl bromide	0.6282	20.10311
acetaldehyde	0.1633	5.22536
acrolein	1.3608	43.54464
benzene	0.4241	13.57141
vinyl chloride	0.4014	12.84567
formaldehyde	0.4989	15.96637
dichloromethane	4.0324	129.03728
phenol	2.7669	88.54077
methanol	19.5044	624.13984
acetone	2.1772	69.67142
methyl ethyl ketone	0.1497	4.78991
methyl l-butyl ketone	12.2469	391.90176
styrene	0.6690	21.40945
toluene	0.5987	19.15964
o-xylene	0.6963	22.28034
1,2-dichloroethane	0.6373	20.39341
1,2,4-trichlorobenzene	1.1793	37.73869

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: Plywood data from NCASI technical bulletin 768, except PM data from NCASI technical bulletin 694. LVL data from NCASI technical bulletin 769.

HOT PRESSING EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.7699	24.63655
alkenes	98.3596	3147.50566
aromatic	17.4509	558.42842
organic w/ chlorine	0.5581	17.85776
xylene	0.3667	11.73596
Specific emissions		
methyl bromide	0.3294	10.54146
acetaldehyde	1.9233	61.54658
acrolein	0.6766	21.65030
benzene	0.2744	8.77957
vinyl chloride	0.2118	6.77878
formaldehyde	2.4673	78.95369
dichloromethane	0.2940	9.40668
phenol	0.1027	3.28487
methanol	68.8704	2203.85121
acetone	3.4133	109.22447
methyl ethyl ketone	0.8539	27.32417
methyl I-butyl ketone	0.0401	1.28409
styrene	0.3630	11.61651
toluene	0.3154	10.09352
o-xylene	0.3667	11.73596
1,2-dichloroethane	0.3453	11.04912
1,2,4-trichlorobenzene	0.6290	20.12731
PM	90.7180	2902.97600

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest
Species: Douglas-fir
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: All data from NCASI technical bulletin 768, except PM data from NCASI technical bulletin 694.

TRIM CYCLONE EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.7257	23.2238
alkenes	59.4203	1901.4493
aromatic	16.3292	522.5357
organic w/ chlorine	0.5216	16.6921
xylene	0.3402	10.8862
Specific emissions		
methyl bromide	0.3039	9.7250
acetaldehyde	0.7257	23.2238
acrolein	0.6350	20.3208
benzene	0.2495	7.9832
vinyl chloride	0.1996	6.3865
formaldehyde	0.1905	6.0962
dichloromethane	0.2722	8.7089
phenol	1.3154	42.0932
methanol	3.4019	108.8616
acetone	0.7257	23.2238
methyl ethyl ketone	0.8165	26.1268
methyl I-butyl ketone	0.7711	24.6753
styrene	0.3357	10.7410
toluene	0.2948	9.4347
o-xylene	0.3402	10.8862
1,2-dichloroethane	0.3175	10.1604
1,2,4-trichlorobenzene	0.5897	18.8693
PM	461.1275	14756.0799

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Southern
Species: Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: All data from NCASI technical bulletin 768, except PM data from NCASI. technical bulletin 694.

TRIM CYCLONE EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.7257	23.2238
alkenes	59.4203	1901.4493
aromatic	16.3292	522.5357
organic w/ chlorine	0.5216	16.6921
xylene	0.3402	10.8862
Specific emissions		
methyl bromide	0.3039	9.7250
acetaldehyde	0.7257	23.2238
acrolein	0.6350	20.3208
benzene	0.2495	7.9832
vinyl chloride	0.1996	6.3865
formaldehyde	0.1905	6.0962
dichloromethane	0.2722	8.7089
phenol	1.3154	42.0932
methanol	3.4019	108.8616
acetone	0.7257	23.2238
methyl ethyl ketone	0.8165	26.1268
methyl l-butyl ketone	0.7711	24.6753
styrene	0.3357	10.7410
toluene	0.2948	9.4347
o-xylene	0.3402	10.8862
1,2-dichloroethane	0.3175	10.1604
1,2,4-trichlorobenzene	0.5897	18.8693
PM	461.1275	14756.0799

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

Description:
Region: Pacific Northwest and Southern
Species: Douglas-fir and Southern Yellow Pine
Manufacturing Process: Plywood and Laminated Veneer Lumber
Data Source: All data from NCASI technical bulletin 768, except PM data from NCASI technical bulletin 694.

SAWDUST CYCLONE EMISSIONS

Groupings	**g/MSF 3/8" basis**	**g/MCF**
aldehydes	0.6350	20.3208
alkenes	50.8021	1625.6666
aromatic	14.5149	464.4762
organic w/ chlorine	0.4581	14.6600
xylene	0.2994	9.5798
Specific emissions		
methyl bromide	0.2676	8.5638
acetaldehyde	0.1950	6.2414
acrolein	0.5443	17.4179
benzene	0.2223	7.1123
vinyl chloride	0.1769	5.6608
formaldehyde	0.1225	3.9190
dichloromethane	0.2404	7.6929
phenol	1.1340	36.2872
methanol	5.4431	174.1786
acetone	0.8618	27.5783
methyl ethyl ketone	0.7257	23.2238
methyl I-butyl ketone	0.6804	21.7723
styrene	0.2948	9.4347
toluene	0.2631	8.4186
o-xylene	0.2994	9.5798
1,2-dichloroethane	0.2812	8.9992
1,2,4-trichlorobenzene	0.4989	15.9664
PM	528.0014	16896.0453

Groupings: (specific chemicals)
Aldehydes: (propionaldehyde)
Alkenes: (camphene; 3-carene; limonene; p-mentha-1,5-diene; alpha-pinene; beta-pinene,)
Aromatic Substance: (cumene; p-cymene)
Organic Substance Containing Chlorine: (ethyl chloride;cis-1,2-dichloroethylene)
Xylene: (m,p-xylene)

APPENDIX C

Table 21: Phenol-formaldehyde production for Douglas-fir in the Pacific Northwest (Source: Forintek Canada Corp, 1993)

Inputs			
Energy feedstock	Gj/metric ton resin	m^3/MSF 3/8" basis	m^3/MCF
Natural Gas	20.5000	10.0250	475.8213
		Gj/MSF 3/8" basis	Gj/MCF
Petroleum	31.4000	0.5839	27.7117
Process Energy		liters/MSF 3/8" basis	liters/MCF
Heavy Oil *	1.4500	0.7930	37.6377
Gasoline **	0.0100	0.0055	0.2596
		m^3/MSF 3/8" basis	m^3/MCF
Natural Gas	26.9000	13.1548	624.3703
		Gj/MSF 3/8" basis	Gj/MCF
Electricity	5.1000	0.0948	4.5010
Transportation Energy		tonne-km/MSF 3/8" basis	tonne-km/MCF
Road ***	1.1700	14.6994	697.6834
Rail ****	0.3400	12.9020	612.3745
Emissions			
Groupings	kg/metric ton resin	lb/MSF 3/8" basis	lb/MCF
aromatic	0.0060	0.0002	0.0116
VOC	1.4850	0.0609	2.8898
Specific Emissions			
formaldehyde	1.3177	0.0540	2.5642
phenol	1.7402	0.0713	3.3864
benzene	0.0007	0.0000	0.0014
NO_X	3.242	0.1329	6.3089
CO	0.998	0.0409	1.9421
CO_2	1551.000	63.5910	3018.2460
SO_2	1.260	0.0517	2.4520
CH_4	0.088	0.0036	0.1712
Particulates	1.6390	0.0672	3.1895

Groupings: (specific chemicals)
Aromatic Substance: (cumene)
VOC: not specified

* Conversion factor used: 34 Gj/1000 liters
** Conversion factor used: 33.6 Gj/1000 liters
*** Conversion factor used: 1.48 Mj/tonne-km
**** Conversion factor used: 0.49 Mj/tonne-km

Table 22: Phenol-formaldehyde production for southern yellow pine in the southern region (Source: Forintek Canada Corp, 1993)

Inputs			
Energy feedstock	Gj/metric ton resin	lb/MSF 3/8" basis	lb/MCF
Natural Gas	20.5000	11.2476	541.1061
		Gj/MSF 3/8" basis	Gj/MCF
Petroleum	31.4000	0.6551	31.5139
Process Energy		liters/MSF 3/8" basis	liters/MCF
Heavy Oil	1.4500	0.8897	42.8018
Gasoline	0.0100	0.0062	0.2987
		m^3/MSF 3/8" basis	m^3/MCF
Natural Gas	26.9000	14.7590	710.0368
		Gj/MSF 3/8" basis	Gj/MCF
Electricity	5.1000	0.1064	5.1185
Transportation Energy		tonne-km/MSF 3/8" basis	tonne-km/MCF
Road ***	1.1700	16.4920	793.4087
Rail ****	0.3400	14.4755	696.3950
Emissions			
Groupings	kg/metric ton resin	lb/MSF 3/8" basis	lb/MCF
aromatic	0.0060	0.0003	0.0132
VOC	1.4850	0.0683	3.2863
Specific Emissions			
formaldehyde	1.3177	0.0606	2.9160
phenol	1.7402	0.0800	3.8511
benzene	0.0007	0.0000	0.0015
NO_X	3.242	0.1491	7.1745
CO	0.998	0.0459	2.2086
CO_2	1551.000	71.3460	3432.3630
SO_2	1.260	0.0580	2.7884
CH_4	0.088	0.0040	0.1947
Particulates	1.6390	0.0754	3.6271

Groupings: (specific chemicals)
Aromatic Substance: (cumene)
VOC: not specified

* Conversion factor used: 34 Gj/1000 liters
** Conversion factor used: 33.6 Gj/1000 liters
*** Conversion factor used: 1.48 Mj/tonne-km
**** Conversion factor used: 0.49 Mj/tonne-km

APPENDIX D

Table 23: Distribution of electrical end-use for plywood mills in Oregon (Source: *Grist and Karmous, 1988 and **Energy Extension Office, 2000)

Description	Percent*	Weighting for Breakdown of End Use Numbers**	Weighted Breakdown of End Use Categories**	
Debarker, Lathe, and Clippers	21	0.44	Debarker	9.2
		0.56	Lathe and Clippers	11.8
Chippers, Conveyors	28	0.8	Chippers	22.4
		0.2	Conveyors	5.6
Dryers	14	1	Dryers	14.0
Hot Presses Lay-up and Finishing	14	0.58	Hot Presses Lay-up	8.1
		0.42	Finishing	5.9
Compressed Air	11	1	Compressed Air	11.0
Lights and Misc.	12	0.52	Lights	6.2
		0.48	Misc	5.8
total	100		total	100

Table 24: Distribution of electrical use by machine center (number from Table 23)

Machine Center	Initial %*	Allocation of chipper electrical use*,**	Allocation of conveyor electrical use*,***	Allocation of light use*,****	Allocation of air compressor use*,*****	% breakdown after allocation
Debarking/Bucking	9.2	-	1.3	-	1.9	12.4
Conditioning	5.8	-	-	-	1.2	6.9
Peeling/Clipping	11.8	-	1.6	1.8	2.4	17.6
Drying	14.0	15.8	1.9	2.2	2.8	36.7
Lay-up/Pressing	8.1	-	-	1.3	1.6	11.0
Trim/Sawing	5.9	6.6	0.8	0.9	1.2	15.4
Total	54.8	22.4	5.6	6.2	11.0	100.0

Note that all allocation done based on intial % usage.

*original data from ODOE report broken down using data from the OSU energy extension office.

**Allocated to the processes for which NCASI has chipper data.

***Allocated to the processes that use conveyors.

****Allocated to processes to would use lighting, mainly indoor processes.

*****Allocated to all processes.

Table 22. Estimates of Energy Input at Electric Utilities, Selected Years 1960-1997, Alabama

Year	Coal: Bituminous Coal and Lignite	Coal: Anthracite	Coal: Total	Natural Gas [a]	Petroleum: Heavy Oil [b,c]	Petroleum: Light Oil [b,d]	Petroleum: Petroleum Coke [b]	Petroleum: Total	Nuclear Electric Power	Hydroelectric Power [e]	Wood and Waste	Geothermal Energy	Other [b,f]	Total [g]
	Thousand Short Tons			Billion Cubic Feet	Thousand Barrels				Million Kilowatthours					
1960	7,264	0	7,264	9	0	(s)	0	(s)	0	8,213	0	0	0	–
1965	12,572	0	12,572	6	0	0	0	0	0	7,078	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	17,301	0	17,301	6	99	514	0	613	2,722	12,188	0	0	0	–
1980	19,593	0	19,593	1	0	131	0	131	23,497	9,385	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	21,436	0	21,436	1	0	67	0	67	11,561	5,227	0	0	0	–
1987	20,746	0	20,746	1	0	58	0	58	11,248	7,449	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	21,884	0	21,884	2	0	216	0	216	11,524	13,153	0	0	0	–
1990	22,010	0	22,010	4	0	133	0	133	12,052	10,367	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	24,988	0	24,988	3	0	141	0	141	19,397	10,260	0	0	0	–
1993	27,533	0	27,533	5	0	130	0	130	17,623	9,634	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	28,759	0	28,759	7	0	181	0	181	20,752	9,502	0	0	0	–
1996	31,216	0	31,216	6	0	299	0	299	29,708	11,082	0	0	0	–
1997	30,841	0	30,841	10	0	230	0	230	29,573	11,521	0	0	0	–
	Trillion Btu													
1960	175.3	0.0	175.3	9.7	0.0	(s)	0.0	(s)	0.0	66.9	0.0	0.0	0.0	251.8
1965	298.0	0.0	298.0	5.8	0.0	0.0	0.0	0.0	0.0	74.0	0.0	0.0	0.0	377.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	400.7	0.0	400.7	6.2	0.6	3.0	0.0	3.6	30.0	126.8	0.0	0.0	0.0	567.4
1980	466.5	0.0	466.5	1.6	0.0	0.8	0.0	0.8	256.3	97.5	0.0	0.0	0.0	824.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	522.0	0.0	522.0	1.2	0.0	0.4	0.0	0.4	124.9	54.6	0.0	0.0	0.0	703.0
1987	507.1	0.0	507.1	1.6	0.0	0.3	0.0	0.3	121.2	77.6	0.0	0.0	0.0	707.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	526.2	0.0	526.2	1.8	0.0	1.3	0.0	1.3	123.6	137.2	0.0	0.0	0.0	790.1
1990	532.4	0.0	532.4	4.2	0.0	0.8	0.0	0.8	128.7	107.8	0.0	0.0	0.0	773.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	602.8	0.0	602.8	3.4	0.0	0.8	0.0	0.8	207.1	106.1	0.0	0.0	0.0	R 920.3
1993	665.9	0.0	665.9	4.7	0.0	0.8	0.0	0.8	190.4	93.1	0.0	0.0	0.0	954.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	682.2	0.0	682.2	7.5	0.0	1.1	0.0	1.1	221.2	R 98.0	0.0	0.0	0.0	1,009.9
1996	736.3	0.0	736.3	6.3	0.0	1.7	0.0	1.7	315.6	R 114.5	0.0	0.0	0.0	1,174.5
1997	714.5	0.0	714.5	10.3	0.0	1.3	0.0	1.3	314.2	118.8	0.0	0.0	0.0	1,159.1

[a] Includes supplemental gaseous fuels.

[b] The continuity of these data series estimates may be affected by changing data sources and estimation methodologies. See the "Additional Notes" under each type of energy in Appendix A.

[c] Prior to 1980, based on oil used in steam plants. Since 1980, heavy oil includes fuel oil nos. 4, 5, and 6 and residual fuel oils.

[d] Prior to 1980, based on oil used in internal combustion and gas turbine engine plants. Since 1980, light oil includes fuel oil nos. 1 and 2, kerosene, and jet fuel.

[e] If applicable, through 1989, includes all net imports of electricity, and, from 1990, includes only the portion of imports of electricity that is derived from hydroelectric power.

[f] "Other" is electricity generated for distribution from wind, photovoltaic, and solar thermal energy.

[g] If applicable, from 1990, includes net imports of electricity generated from nonrenewable energy sources not shown in other columns. See data in appendix Table A8.

R=Revised data.

– =Not applicable.

(s)=Btu value less than 0.05 and physical unit value less than 0.5.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Data sources, estimation procedures, and assumptions are described in the appendices to this report.

Table 82. Estimates of Energy Input at Electric Utilities, Selected Years 1960-1997, Georgia

Year	Coal: Bituminous Coal and Lignite	Coal: Anthracite	Coal: Total	Natural Gas[a]	Petroleum: Heavy Oil[b,c]	Petroleum: Light Oil[b,d]	Petroleum: Petroleum Coke[b]	Petroleum: Total	Nuclear Electric Power	Hydroelectric Power[e]	Wood and Waste	Geothermal Energy	Other[b,f]	Total[g]
	Thousand Short Tons			Billion Cubic Feet	Thousand Barrels				Million Kilowatthours					
1960	2,608	0	2,608	25	39	1	0	40	0	2,243	0	0	0	–
1965	5,291	0	5,291	1	52	2	0	54	0	3,170	0	0	0	–
[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	0	[illegible]	0	[illegible]	0	[illegible]
1975	12,656	0	12,656	40	4,059	1,077	0	5,136	3,093	4,278	0	0	0	–
1980	21,191	0	21,191	4	670	415	0	1,085	8,436	4,369	0	0	0	–
[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	0	[illegible]	0	[illegible]
1986	26,652	0	26,652	6	356	169	0	525	7,238	2,097	0	0	0	–
1987	27,130	0	27,130	1	207	154	0	361	15,259	3,121	0	0	0	–
[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]
1989	25,839	0	25,839	1	27	318	0	346	24,961	3,874	0	0	0	–
1990	27,812	0	27,812	2	115	218	0	333	24,797	4,887	0	0	0	–
[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	0	[illegible]	0	[illegible]
1992	23,656	0	23,656	1	69	199	0	268	27,996	5,342	0	0	0	–
1993	25,339	0	25,339	3	170	336	0	506	27,233	4,753	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	0	[illegible]	0	[illegible]
1995	29,280	0	29,280	8	109	385	0	494	30,661	4,684	0	0	0	–
1996	29,170	0	29,170	5	84	555	0	640	29,925	4,936	0	0	0	–
1997	30,631	0	30,631	7	81	370	0	451	30,414	4,418	0	0	0	–
	Trillion Btu													
1960	65.3	0.0	65.3	26.2	0.2	(s)	0.0	0.3	0.0	24.1	0.0	0.0	0.0	115.9
1965	131.9	0.0	131.9	0.9	0.3	(s)	0.0	0.3	0.0	33.1	0.0	0.0	0.0	166.3
[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]
1975	300.6	0.0	300.6	41.5	25.5	6.3	0.0	31.8	34.1	44.5	0.0	0.0	0.0	452.4
1980	504.5	0.0	504.5	3.8	4.2	2.4	0.0	6.6	92.0	45.4	0.0	0.0	0.0	652.3
[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]
1986	647.4	0.0	647.4	5.9	2.2	1.0	0.0	3.2	78.2	21.9	0.0	0.0	0.0	756.7
1987	660.6	0.0	660.6	0.8	1.3	0.9	0.0	2.2	164.4	32.5	0.0	0.0	0.0	860.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	625.3	0.0	625.3	0.7	0.2	1.9	0.0	2.0	267.7	40.4	0.0	0.0	0.0	936.1
1990	661.5	0.0	661.5	2.0	0.7	1.3	0.0	2.0	264.8	50.8	0.0	0.0	0.0	981.2
[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0	[illegible]
1992	569.6	0.0	569.6	1.2	0.4	1.2	0.0	1.6	298.9	56.2	0.0	0.0	0.0	926.6
1993	615.6	0.0	615.6	3.1	1.1	2.0	0.0	3.0	290.9	49.0	0.0	0.0	0.0	961.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]	0.0	[illegible]	0.0	[illegible]
1995	677.9	0.0	677.9	8.0	0.7	2.2	0.0	2.9	326.8	48.3	0.0	0.0	0.0	1,063.9
1996	675.6	0.0	675.6	4.8	0.5	3.2	0.0	3.8	317.9	51.0	0.0	0.0	0.0	1,053.2
1997	720.2	0.0	720.2	7.5	0.5	2.2	0.0	2.7	323.1	45.6	0.0	0.0	0.0	1,099.0

[a] Includes supplemental gaseous fuels.

[b] The continuity of these data series estimates may be affected by changing data sources and estimation methodologies. See the "Additional Notes" under each type of energy in Appendix A.

[c] Prior to 1980, based on oil used in steam plants. Since 1980, heavy oil includes fuel oil nos. 4, 5, and 6 and residual fuel oils.

[d] Prior to 1980, based on oil used in internal combustion and gas turbine engine plants. Since 1980, light oil includes fuel oil nos. 1 and 2, kerosene, and jet fuel.

[e] If applicable, through 1989, includes all net imports of electricity, and, from 1990, includes only the portion of imports of electricity that is derived from hydroelectric power.

[f] "Other" is electricity generated for distribution from wind, photovoltaic, and solar thermal energy.

[g] If applicable, from 1990, includes net imports of electricity generated from nonrenewable energy sources not shown in other columns. See data in appendix Table A8.

R=Revised data.

– =Not applicable.

(s)=Btu value less than 0.05 and physical unit value less than 0.5.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Data sources, estimation procedures, and assumptions are described in the appendices to this report.

Figure 24: Electricity generation in Georgia

Table 130. Estimates of Energy Input at Electric Utilities, Selected Years 1960-1997, Louisiana

Year	Coal: Bituminous Coal and Lignite	Coal: Anthracite	Coal: Total	Natural Gas [a]	Petroleum: Heavy Oil [b,c]	Petroleum: Light Oil [b,d]	Petroleum: Petroleum Coke [b]	Petroleum: Total	Nuclear Electric Power	Hydroelectric Power [e]	Wood and Waste	Geothermal Energy	Other [b,f]	Total [g]
	Thousand Short Tons			Billion Cubic Feet	Thousand Barrels				Million Kilowatthours					
1960	0	0	0	120	36	22	0	58	0	0	0	0	0	–
1965	(s)	0	(s)	176	34	20	0	54	0	0	0	0	0	–
1970	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	0	0	0	356	5,699	88	0	5,787	0	0	0	0	0	–
1980	0	0	0	425	7,096	1,174	0	8,270	0	0	0	0	0	–
1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	10,196	0	10,196	266	631	77	0	709	10,637	0	0	0	0	–
1987	10,029	0	10,029	247	49	69	0	118	12,324	0	0	0	0	–
1988	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	11,770	0	11,770	245	225	297	0	521	12,391	0	0	0	0	–
1990	11,748	0	11,748	269	75	159	0	234	14,197	0	0	0	0	–
1991	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	13,077	0	13,077	255	18	75	873	966	10,356	0	0	0	0	–
1993	13,069	0	13,069	244	634	69	2,749	3,452	14,398	0	0	0	0	–
1994	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	12,930	0	12,930	323	13	78	0	91	15,686	0	0	0	0	–
1996	12,450	0	12,450	252	308	198	0	507	15,765	0	0	0	0	–
1997	13,807	0	13,807	277	1,024	86	0	1,111	13,511	0	0	0	0	–
	Trillion Btu													
1960	0.0	0.0	0.0	124.0	0.2	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	124.4
1965	(s)	0.0	(s)	182.9	0.2	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	183.3
1970	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	0.0	0.0	0.0	377.1	35.8	0.5	0.0	36.3	0.0	0.0	0.0	0.0	0.0	413.5
1980	0.0	0.0	0.0	442.4	44.6	6.8	0.0	51.5	0.0	0.0	0.0	0.0	0.0	493.9
1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	165.6	0.0	165.6	279.6	4.0	0.5	0.0	4.4	114.9	0.0	0.0	0.0	0.0	564.5
1987	163.7	0.0	163.7	257.5	0.3	0.4	0.0	0.7	132.8	0.0	0.0	0.0	0.0	554.7
1988	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	192.7	0.0	192.7	255.8	1.4	1.7	0.0	3.1	132.9	0.0	0.0	0.0	0.0	584.5
1990	192.5	0.0	192.5	280.8	0.5	0.9	0.0	1.4	151.6	0.0	0.0	0.0	0.0	626.4
1991	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	212.4	0.0	212.4	265.9	0.1	0.4	5.3	5.8	110.6	0.0	0.0	0.0	0.0	594.7
1993	211.8	0.0	211.8	254.5	4.0	0.4	16.6	20.9	153.8	0.0	0.0	0.0	0.0	641.1
1994	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	209.7	0.0	209.7	336.8	0.1	0.5	0.0	0.5	167.2	0.0	0.0	0.0	0.0	714.2
1996	203.5	0.0	203.5	263.0	1.9	1.2	0.0	3.1	167.5	0.0	0.0	0.0	0.0	637.0
1997	223.7	0.0	223.7	287.4	6.4	0.5	0.0	6.9	143.5	0.0	0.0	0.0	0.0	661.6

[a] Includes supplemental gaseous fuels.
[b] The continuity of these data series estimates may be affected by changing data sources and estimation methodologies. See the "Additional Notes" under each type of energy in Appendix A.
[c] Prior to 1980, based on oil used in steam plants. Since 1980, heavy oil includes fuel oil nos. 4, 5, and 6 and residual fuel oils.
[d] Prior to 1980, based on oil used in internal combustion and gas turbine engine plants. Since 1980, light oil includes fuel oil nos. 1 and 2, kerosene, and jet fuel.
[e] If applicable, through 1989, includes all net imports of electricity, and, from 1990, includes only the portion of imports of electricity that is derived from hydroelectric power.
[f] "Other" is electricity generated for distribution from wind, photovoltaic, and solar thermal energy.
[g] If applicable, from 1990, includes net imports of electricity generated from nonrenewable energy sources not shown in other columns. See data in appendix Table A8.
– =Not applicable.
(s)=Btu value less than 0.05 and physical unit value less than 0.5.
Note: Totals may not equal sum of components due to independent rounding.
Sources: Data sources, estimation procedures, and assumptions are described in the appendices to this report.

Table 166. Estimates of Energy Input at Electric Utilities, Selected Years 1960-1997, Mississippi

Year	Coal: Bituminous Coal and Lignite	Coal: Anthracite	Coal: Total	Natural Gas[a]	Petroleum: Heavy Oil[b,c]	Petroleum: Light Oil[b,d]	Petroleum: Petroleum Coke[b]	Petroleum: Total	Nuclear Electric Power	Hydroelectric Power[e]	Wood and Waste	Geothermal Energy	Other[b,f]	Total[g]
	Thousand Short Tons			Billion Cubic Feet	Thousand Barrels				Million Kilowatthours					
1960	8	0	8	34	64	1	0	65	0	0	0	0	0	–
1965	9	0	9	56	6	(s)	0	7	0	0	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	1,416	0	1,416	32	9,203	266	0	9,469	0	0	0	0	0	–
1980	3,072	0	3,072	96	5,078	70	0	5,149	0	0	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	4,208	0	4,208	48	1,374	45	0	1,420	4,087	0	0	0	0	–
1987	4,562	0	4,562	41	152	37	0	188	7,717	0	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	3,566	0	3,566	45	1,277	86	0	1,363	7,826	0	0	0	0	–
1990	3,888	0	3,888	65	1,179	50	0	1,228	7,422	0	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	3,237	0	3,237	54	623	28	0	651	8,174	0	0	0	0	–
1993	3,767	0	3,767	40	5,503	35	0	5,538	7,904	0	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	4,319	0	4,319	111	7	41	0	48	8,013	0	0	0	0	–
1996	5,558	0	5,568	83	1,703	89	0	1,792	9,225	0	0	0	0	–
1997	6,035	0	6,035	73	4,035	51	0	4,086	10,813	0	0	0	0	–
	Trillion Btu													
1960	0.2	0.0	0.2	35.6	0.4	(s)	0.0	0.4	0.0	0.0	0.0	0.0	0.0	36.2
1965	0.2	0.0	0.2	58.0	(s)	(s)	0.0	(s)	0.0	0.0	0.0	0.0	0.0	58.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	32.8	0.0	32.8	32.5	57.9	1.5	0.0	59.4	0.0	0.0	0.0	0.0	0.0	124.7
1980	73.7	0.0	73.7	96.7	31.9	0.4	0.0	32.3	0.0	0.0	0.0	0.0	0.0	202.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	102.9	0.0	102.9	49.4	8.6	0.3	0.0	8.9	44.1	0.0	0.0	0.0	0.0	205.4
1987	115.6	0.0	115.6	42.3	1.0	0.2	0.0	1.2	83.2	0.0	0.0	0.0	0.0	242.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	90.2	0.0	90.2	46.0	8.0	0.5	0.0	8.5	83.9	0.0	0.0	0.0	0.0	228.7
1990	97.5	0.0	97.5	67.5	7.4	0.3	0.0	7.7	79.3	0.0	0.0	0.0	0.0	252.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	81.0	0.0	81.0	55.6	3.9	0.2	0.0	4.1	87.3	0.0	0.0	0.0	0.0	228.1
1993	93.0	0.0	93.0	40.8	34.6	0.2	0.0	34.8	84.4	0.0	0.0	0.0	0.0	253.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	96.9	0.0	96.9	115.6	(s)	0.2	0.0	0.3	85.4	0.0	0.0	0.0	0.0	298.2
1996	122.5	0.0	122.5	86.4	10.7	0.5	0.0	11.2	98.0	0.0	0.0	0.0	0.0	318.2
1997	126.6	0.0	126.6	75.7	25.4	0.3	0.0	25.7	114.9	0.0	0.0	0.0	0.0	342.8

[a] Includes supplemental gaseous fuels.

[b] The continuity of these data series estimates may be affected by changing data sources and estimation methodologies. See the "Additional Notes" under each type of energy in Appendix A.

[c] Prior to 1980, based on oil used in steam plants. Since 1980, heavy oil includes fuel oil nos. 4, 5, and 6 and residual fuel oils.

[d] Prior to 1980, based on oil used in internal combustion and gas turbine engine plants. Since 1980, light oil includes fuel oil nos. 1 and 2, kerosene, and jet fuel.

[e] If applicable, through 1989, includes all net imports of electricity, and, from 1990, includes only the portion of imports of electricity that is derived from hydroelectric power.

[f] "Other" is electricity generated for distribution from wind, photovoltaic, and solar thermal energy.

[g] If applicable, from 1990, includes net imports of electricity generated from nonrenewable energy sources not shown in other columns. See data in appendix Table A8.

– =Not applicable.

(s)=Btu value less than 0.05 and physical unit value less than 0.5.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Data sources, estimation procedures, and assumptions are described in the appendices to this report.

Table 244. Estimates of Energy Input at Electric Utilities, Selected Years 1960-1997, Oregon

Year	Coal: Bituminous Coal and Lignite	Coal: Anthracite	Coal: Total	Natural Gas [a]	Petroleum: Heavy Oil [b,c]	Petroleum: Light Oil [b,d]	Petroleum: Petroleum Coke [b]	Petroleum: Total	Nuclear Electric Power	Hydroelectric Power [e]	Wood and Waste	Geothermal Energy	Other [b,f]	Total [g]
	Thousand Short Tons			Billion Cubic Feet	Thousand Barrels				Million Kilowatthours					
1960	0	0	0	1	3	(s)	0	3	0	12,389	24	0	0	–
1965	0	0	0	(s)	1	(s)	0	1	0	16,447	26	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	0	0	0	(s)	0	29	0	29	2	34,522	(s)	0	0	–
1980	485	0	485	(s)	0	110	0	110	5,396	30,194	160	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	0	0	0	(s)	0	4	0	4	7,081	42,068	0	0	0	–
1987	0	0	0	0	0	2	0	2	4,348	40,689	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	306	0	306	13	0	76	0	76	5,299	R 39,503	28	0	0	–
1990	850	0	850	7	0	56	0	56	6,074	42,682	1	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	1,994	0	1,994	14	0	19	0	19	4,573	36,209	6	0	0	–
1993	1,961	0	1,961	16	0	56	0	56	-21	38,066	11	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	977	0	977	19	0	12	0	12	0	41,499	0	0	0	–
1996	1,044	0	1,044	14	0	10	0	10	0	47,117	0	0	0	–
1997	822	0	822	11	0	23	0	23	0	46,736	0	0	0	–
	Trillion Btu													
1960	0.0	0.0	0.0	0.7	(s)	(s)	0.0	(s)	0.0	133.3	0.3	0.0	0.0	134.3
1965	0.0	0.0	0.0	0.1	(s)	(s)	0.0	(s)	0.0	171.9	0.3	0.0	0.0	172.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	0.0	0.0	0.0	(s)	0.0	0.2	0.0	0.2	(s)	359.2	(s)	0.0	0.0	359.4
1980	7.9	0.0	7.9	0.3	0.0	0.6	0.0	0.6	58.8	313.7	1.7	0.0	0.0	383.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	0.0	0.0	0.0	(s)	0.0	(s)	0.0	(s)	76.5	439.4	0.0	0.0	0.0	515.9
1987	0.0	0.0	0.0	0.0	0.0	(s)	0.0	(s)	46.9	423.9	0.0	0.0	0.0	470.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	5.2	0.0	5.2	13.4	0.0	0.4	0.0	0.4	56.8	R 412.1	0.3	0.0	0.0	492.9
1990	14.2	0.0	14.2	7.8	0.0	0.3	0.0	0.3	64.9	R 444.0	(s)	0.0	0.0	R 535.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	38.4	0.0	38.4	14.4	0.0	0.1	0.0	0.1	48.8	R 374.5	0.1	0.0	0.0	R 491.3
1993	34.9	0.0	34.9	16.3	0.0	0.3	0.0	0.3	-0.2	392.4	0.1	0.0	0.0	451.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	17.4	0.0	17.4	19.4	0.0	0.1	0.0	0.1	0.0	R 427.9	0.0	0.0	0.0	R 470.6
1996	18.3	0.0	18.3	14.1	0.0	0.1	0.0	0.1	0.0	R 467.0	0.0	0.0	0.0	R 529.1
1997	14.4	0.0	14.4	10.8	0.0	0.1	0.0	0.1	0.0	481.9	0.0	0.0	0.0	510.5

[a] Includes supplemental gaseous fuels.

[b] The continuity of these data series estimates may be affected by changing data sources and estimation methodologies. See the "Additional Notes" under each type of energy in Appendix A.

[c] Prior to 1980, based on oil used in steam plants. Since 1980, heavy oil includes fuel oil nos. 4, 5, and 6 and residual fuel oils.

[d] Prior to 1980, based on oil used in internal combustion and gas turbine engine plants. Since 1980, light oil includes fuel oil nos. 1 and 2, kerosene, and jet fuel.

[e] If applicable, through 1989, includes all net imports of electricity, and, from 1990, includes only the portion of imports of electricity that is derived from hydroelectric power.

[f] "Other" is electricity generated for distribution from wind, photovoltaic, and solar thermal energy.

[g] If applicable, from 1990, includes net imports of electricity generated from nonrenewable energy sources not shown in other columns. See data in appendix Table A5.

R=Revised data.

– =Not applicable.

(s)=Btu value less than 0.05 and physical unit value less than 0.5.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Data sources, estimation procedures, and assumptions are described in the appendices to this report.

Table 304. Estimates of Energy Input at Electric Utilities, Selected Years 1960-1997, Washington

Year	Coal: Bituminous Coal and Lignite	Coal: Anthracite	Coal: Total	Natural Gas [a]	Petroleum: Heavy Oil [b,c]	Petroleum: Light Oil [b,d]	Petroleum: Petroleum Coke [b]	Petroleum: Total	Nuclear Electric Power	Hydroelectric Power [e]	Wood and Waste	Geothermal Energy	Other [b,f]	Total [g]
	Thousand Short Tons			Billion Cubic Feet	Thousand Barrels				Million Kilowatthours					
1960	0	0	0	0	14	2	0	16	0	34,104	1	0	0	–
1965	0	0	0	0	3	(s)	0	3	0	48,624	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	4,009	0	4,009	0	71	4	0	75	3,308	85,257	0	0	0	–
1980	4,950	0	4,950	1	201	31	0	232	2,041	83,841	0	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	3,329	0	3,329	(s)	1	19	0	20	8,439	76,509	191	0	0	–
1987	5,468	0	5,468	(s)	1	17	0	18	5,528	70,834	348	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	5,514	0	5,514	8	150	42	0	192	6,118	R 69,864	376	0	0	–
1990	4,852	0	4,852	(s)	1	30	0	31	5,742	85,167	333	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	6,148	0	6,148	5	1	12	0	13	5,692	68,864	361	0	0	–
1993	5,646	0	5,646	5	1	62	0	62	7,135	64,263	395	0	0	–
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	3,857	0	3,857	6	0	18	0	18	6,942	80,406	261	0	0	–
1996	5,507	0	5,507	7	0	16	0	16	5,588	100,688	360	0	0	–
1997	4,771	0	4,771	3	0	39	0	39	6,244	102,129	353	0	0	–
	Trillion Btu													
1960	0.0	0.0	0.0	0.0	0.1	(s)	0.0	0.1	0.0	367.0	(s)	0.0	0.0	367.1
1965	0.0	0.0	0.0	0.0	(s)	(s)	0.0	(s)	0.0	508.3	0.0	0.0	0.0	508.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	64.9	0.0	64.9	0.0	0.4	(s)	0.0	0.5	36.4	887.2	0.0	0.0	0.0	989.0
1980	80.2	0.0	80.2	1.0	1.3	0.2	0.0	1.4	22.3	870.9	0.0	0.0	0.0	975.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986	53.9	0.0	53.9	0.1	(s)	0.1	0.0	0.1	91.1	799.2	2.0	0.0	0.0	946.5
1987	88.6	0.0	88.6	0.1	(s)	0.1	0.0	0.1	59.6	736.0	3.6	0.0	0.0	890.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1989	90.0	0.0	90.0	8.6	0.9	0.2	0.0	1.2	65.6	R 728.8	3.9	0.0	0.0	904.8
1990	78.9	0.0	78.9	0.2	(s)	0.2	0.0	0.2	61.3	R 885.9	3.5	0.0	0.0	R 1,035.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992	100.7	0.0	100.7	5.7	(s)	0.1	0.0	0.1	60.8	R 691.5	3.7	0.0	0.0	R 869.2
1993	91.7	0.0	91.7	5.1	(s)	0.4	0.0	0.4	76.2	662.5	4.1	0.0	0.0	834.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	63.8	0.0	63.8	6.7	0.0	0.1	0.0	0.1	74.0	R 829.1	2.7	0.0	0.0	R 950.3
1996	87.4	0.0	87.4	6.9	0.0	0.1	0.0	0.1	59.4	R 1,040.6	3.7	0.0	0.0	R 1,185.6
1997	76.7	0.0	76.7	2.7	0.0	0.2	0.0	0.2	66.3	1,053.1	3.6	0.0	0.0	1,205.0

[a] Includes supplemental gaseous fuels.

[b] The continuity of these data series estimates may be affected by changing data sources and estimation methodologies. See the "Additional Notes" under each type of energy in Appendix A.

[c] Prior to 1980, based on oil used in steam plants. Since 1980, heavy oil includes fuel oil nos. 4, 5, and 6 and residual fuel oils.

[d] Prior to 1980, based on oil used in internal combustion and gas turbine engine plants. Since 1980, light oil includes fuel oil nos. 1 and 2, kerosene, and jet fuel.

[e] Through 1989, includes all net imports of electricity, and, from 1990, includes only the portion of net imports of electricity that is derived from hydroelectric power.

[f] "Other" is electricity generated for distribution from wind, photovoltaic, and solar thermal energy.

[g] If applicable, from 1990, includes net imports of electricity generated from nonrenewable energy sources not shown in other columns. See data in appendix Table A8.

R=Revised data.

– =Not applicable.

(s)=Btu value less than 0.05 and physical unit value less than 0.5.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Data sources, estimation procedures, and assumptions are described in the appendices to this report.

APPENDIX E

Pacific Northwest plywood machine center energy distribution (MJ/MSF 3/8" basis):

Electricity Consumption:	562 MJ
Heat Consumption:	3,452 MJ

Debarking and Bucking:			
Electricity from coal:	3 MJ		
Electricity from nat. gas:	1 MJ		
Electricity from uranuim:	3 MJ		
Electricity from hydro:	61 MJ		
Conditioning:			
Electricity from coal:	2 MJ		
Electricity from nat. gas:	0 MJ		
Electricity from uranuim:	2 MJ		
Electricity from hydro:	40 MJ		
Heat from hog fuel:	769 MJ		
Heat from nat. gas:	236 MJ		
Heat from DFO:	20 MJ		
Heat from LPG:	10 MJ		
Peeling and Clipping:			
Electricity from coal:	5 MJ		
Electricity from nat. gas:	1 MJ		
Electricity from uranuim:	4 MJ		
Electricity from hydro:	86 MJ		
Drying:		**Chipping:**	
Electricity from coal:	5 MJ	Electricity from coal:	1 MJ
Electricity from nat. gas:	1 MJ	Electricity from nat. gas:	0 MJ
Electricity from uranuim:	4 MJ	Electricity from uranuim:	1 MJ
Electricity from hydro:	96 MJ	Electricity from hydro:	25 MJ
Heat from hog fuel:	1,409 MJ		
Heat from nat. gas:	433 MJ		
Heat from DFO:	37 MJ		
Heat from LPG:	18 MJ		
Pressing:			
Electricity from coal:	3 MJ		
Electricity from nat. gas:	1 MJ		
Electricity from uranuim:	3 MJ		
Electricity from hydro:	61 MJ		
Heat from hog fuel:	384 MJ		
Heat from nat. gas:	118 MJ		
Heat from DFO:	10 MJ		
Heat from LPG:	5 MJ		
Trimming and Sawing:		**Chipping:**	
Electricity from coal:	3 MJ	Electricity from coal:	5 MJ
Electricity from nat. gas:	1 MJ	Electricity from nat. gas:	1 MJ
Electricity from uranuim:	2 MJ	Electricity from uranuim:	4 MJ
Electricity from hydro:	51 MJ	Electricity from hydro:	86 MJ

Pacific Northwest LVL machine center energy distribution (MJ/MCF):

Electricity Consumption:	17,995 MJ
Heat Consumption:	110,471 MJ

Debarking and Bucking:

Electricity from coal:	108 MJ
Electricity from nat. gas:	22 MJ
Electricity from uranuim:	86 MJ
Electricity from hydro:	1,943 MJ

Conditioning:

Electricity from coal:	72 MJ
Electricity from nat. gas:	14 MJ
Electricity from uranuim:	58 MJ
Electricity from hydro:	1,296 MJ
Heat from hog fuel:	24,599 MJ
Heat from nat. gas:	7,564 MJ
Heat from DFO:	650 MJ
Heat from LPG:	308 MJ

Peeling and Clipping:

Electricity from coal:	153 MJ
Electricity from nat. gas:	31 MJ
Electricity from uranuim:	122 MJ
Electricity from hydro:	2,753 MJ

Drying:

Electricity from coal:	171 MJ
Electricity from nat. gas:	34 MJ
Electricity from uranuim:	137 MJ
Electricity from hydro:	3,077 MJ
Heat from hog fuel:	45,098 MJ
Heat from nat. gas:	13,867 MJ
Heat from DFO:	1,191 MJ
Heat from LPG:	564 MJ

Chipping:

Electricity from coal:	45 MJ
Electricity from nat. gas:	9 MJ
Electricity from uranuim:	36 MJ
Electricity from hydro:	810 MJ

Pressing:

Electricity from coal:	108 MJ
Electricity from nat. gas:	22 MJ
Electricity from uranuim:	86 MJ
Electricity from hydro:	1,943 MJ
Heat from hog fuel:	12,299 MJ
Heat from nat. gas:	3,782 MJ
Heat from DFO:	325 MJ
Heat from LPG:	154 MJ

Trimming and Sawing:

Electricity from coal:	90 MJ
Electricity from nat. gas:	18 MJ
Electricity from uranuim:	72 MJ
Electricity from hydro:	1,620 MJ

Chipping:

Electricity from coal:	153 MJ
Electricity from nat. gas:	31 MJ
Electricity from uranuim:	122 MJ
Electricity from hydro:	2,753 MJ

Southern plywood machine center energy distribution (MJ/MSF 3/8" basis):

Electricity Consumption:	395 MJ
Heat Consumption:	3,975 MJ
Debarking and Bucking:	
Electricity from coal:	26 MJ
Electricity from nat. gas:	6 MJ
Electricity from uranuim:	13 MJ
Electricity from hydro:	2 MJ
Electricity from petroleum:	0 MJ
Conditioning:	
Electricity from coal:	17 MJ
Electricity from nat. gas:	4 MJ
Electricity from uranuim:	9 MJ
Electricity from hydro:	2 MJ
Electricity from petroleum:	0 MJ
Heat from hog fuel:	595 MJ
Heat from nat. gas:	576 MJ
Heat from DFO:	10 MJ
Heat from LPG:	11 MJ
Peeling and Clipping:	
Electricity from coal:	37 MJ
Electricity from nat. gas:	8 MJ
Electricity from uranuim:	18 MJ
Electricity from hydro:	3 MJ
Electricity from petroleum:	1 MJ
Drying:	
Electricity from coal:	41 MJ
Electricity from nat. gas:	9 MJ
Electricity from uranuim:	20 MJ
Electricity from hydro:	4 MJ
Electricity from petroleum:	1 MJ
Heat from hog fuel:	1,091 MJ
Heat from nat. gas:	1,056 MJ
Heat from DFO:	18 MJ
Heat from LPG:	20 MJ
Pressing:	
Electricity from coal:	26 MJ
Electricity from nat. gas:	6 MJ
Electricity from uranuim:	13 MJ
Electricity from hydro:	2 MJ
Electricity from petroleum:	0 MJ
Heat from hog fuel:	298 MJ
Heat from nat. gas:	288 MJ
Heat from DFO:	5 MJ
Heat from LPG:	5 MJ
Trimming and Sawing:	
Electricity from coal:	22 MJ
Electricity from nat. gas:	5 MJ
Electricity from uranuim:	11 MJ
Electricity from hydro:	2 MJ
Electricity from petroleum:	0 MJ

Chipping:	
Electricity from coal:	11 MJ
Electricity from nat. gas:	2 MJ
Electricity from uranuim:	5 MJ
Electricity from hydro:	1 MJ
Electricity from petroleum:	0 MJ
Chipping:	
Electricity from coal:	37 MJ
Electricity from nat. gas:	8 MJ
Electricity from uranuim:	18 MJ
Electricity from hydro:	3 MJ
Electricity from petroleum:	1 MJ

Southeast LVL machine center energy distribution (MJ/MCF):

Electricity Consumption:	12,642 MJ
Heat Consumption:	127,195 MJ
Debarking and Bucking:	
Electricity from coal:	834 MJ
Electricity from nat. gas:	182 MJ
Electricity from uranuim:	410 MJ
Electricity from hydro:	76 MJ
Electricity from petroleum:	15 MJ
Conditioning:	
Electricity from coal:	556 MJ
Electricity from nat. gas:	121 MJ
Electricity from uranuim:	273 MJ
Electricity from hydro:	51 MJ
Electricity from petroleum:	10 MJ
Heat from hog fuel:	19,041 MJ
Heat from nat. gas:	18,440 MJ
Heat from DFO:	316 MJ
Heat from LPG:	347 MJ
Peeling and Clipping:	
Electricity from coal:	1,182 MJ
Electricity from nat. gas:	258 MJ
Electricity from uranuim:	580 MJ
Electricity from hydro:	107 MJ
Electricity from petroleum:	21 MJ
Drying:	
Electricity from coal:	1,321 MJ
Electricity from nat. gas:	288 MJ
Electricity from uranuim:	649 MJ
Electricity from hydro:	120 MJ
Electricity from petroleum:	24 MJ
Heat from hog fuel:	34,909 MJ
Heat from nat. gas:	33,807 MJ
Heat from DFO:	580 MJ
Heat from LPG:	636 MJ
Chipping:	
Electricity from coal:	348 MJ
Electricity from nat. gas:	76 MJ
Electricity from uranuim:	171 MJ
Electricity from hydro:	32 MJ
Electricity from petroleum:	6 MJ
Pressing:	
Electricity from coal:	834 MJ
Electricity from nat. gas:	182 MJ
Electricity from uranuim:	410 MJ
Electricity from hydro:	76 MJ
Electricity from petroleum:	15 MJ
Heat from hog fuel:	9,521 MJ
Heat from nat. gas:	9,220 MJ
Heat from DFO:	158 MJ
Heat from LPG:	173 MJ
Trimming and Sawing:	
Electricity from coal:	695 MJ
Electricity from nat. gas:	152 MJ
Electricity from uranuim:	341 MJ
Electricity from hydro:	63 MJ
Electricity from petroleum:	13 MJ
Chipping:	
Electricity from coal:	1,182 MJ
Electricity from nat. gas:	258 MJ
Electricity from uranuim:	580 MJ
Electricity from hydro:	107 MJ
Electricity from petroleum:	21 MJ

APPENDIX F

Figure 29: Substances included in the damage categories for the Eco-indicator99 methodology. This list includes normalized and weighted damage factors for each substance (Source: Goedkoop and Spriensma, 2000).

1 Damage factors in the hierarchist perspective (default) (H,A)

This annex lists the Eco-indicator 99 damage factors for the substance lists that can be found in most popular LCA databases. In this case the hierarchist perspective is used, combined with the default (average) weighting factors. Next to the damage factors two columns are added with the normalised and weighted damages. The normalisation factors and the weights are specified below:

	Normalisation	Weights
Human Health	1.54E-02	400
Ecosystem Quality	5.13E+03	400
Resources	8.41E+03	200

Below the impact categories are listed per damage category.

1.1 Damage category Human Health (H,A)

The human health damages are specified in DALYs. This is short for Disability Adjusted Life Years. A damage of 1 means one life year of one individual is lost, or one person suffers four year from a disability with a weight of 0.25.

1.1.1 Carcinogenic effects on humans (H,A)

For the fate and exposure it is important to distinguish emissions to soil between emissions in industrial (ind.) or agricultural (agr.) soil. All emissions of pesticides are assumed to occur in agricultural soil, all other emissions are assumed to occur in industrial (or urban) soil. No direct emissions are assumed to occur in natural soil.
Fate factors are calculated with EUSES. Substances from IARC substances groups 1, 2a and 2b are included.

All damage factors are expressed per kg emission. The unit of damage is DALYs.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	1,2-dibromoethane	2.60E-04	1.69E-02	6.75E+00
Air	1,2-dichloroethane	2.98E-05	1.94E-03	7.74E-01
Air	1,3-butadiene	1.58E-05	1.03E-03	4.10E-01
Air	1,4-dioxane	1.39E-07	9.03E-06	3.61E-03
Air	2,4,6-trichlorophenol	2.05E-06	1.33E-04	5.32E-02
Air	acetaldehyde	2.16E-07	1.40E-05	5.61E-03
Air	acrylonitrile	1.69E-05	1.10E-03	4.39E-01
Air	alpha-hexachlorocyclohexan	3.00E-04	1.95E-02	7.79E+00
Air	Arsenic	2.46E-02	1.60E+00	6.39E+02
Air	Bis(chloromethyl)ether	7.48E-03	4.86E-01	1.94E+02
Air	benzene	2.50E-06	1.62E-04	6.49E-02
Air	benzo(a)anthracene	5.86E-02	3.81E+00	1.52E+03
Air	benzo(a)pyrene	3.98E-03	2.58E-01	1.03E+02
Air	benzotrichloride	6.60E-03	4.29E-01	1.71E+02
Air	benzylchloride	1.04E-05	6.75E-04	2.70E-01
Air	beta-chlorocyclohexan	9.99E-05	6.49E-03	2.59E+00
Air	bromodichloromethane	8.76E-06	5.69E-04	2.28E-01
Air	Cadmium	1.35E-01	8.77E+00	3.51E+03
Air	Chromium (VI)	1.75	1.14E+02	4.55E+04
Air	di(2-ethylhexyl)phthalate	3.38E-05	2.19E-03	8.78E-01
Air	dibenz(a)anthracene	3.10E+01	2.01E+03	8.05E+05
Air	dichloromethane	4.36E-07	2.83E-05	1.13E-02
Air	Dichlorvos	3.15E-05	2.05E-03	8.18E-01
Air	2,3,7,8-TCDD Dioxin	1.79E+02	1.16E+04	4.65E+06
Air	epichlorohydrin	3.02E-07	1.96E-05	7.84E-03
Air	ethylene oxide	1.83E-04	1.19E-02	4.75E+00
Air	formaldehyde	9.91E-07	6.44E-05	2.57E-02
Air	gamma-HCH (Lindane)	3.49E-04	2.27E-02	9.06E+00
Air	Hexachlorobenzene	8.25E-02	5.36E+00	2.14E+03
Air	metals	5.20E-03	3.38E-01	1.35E+02
Air	Nickel	2.35E-02	1.53E+00	6.10E+02
Air	Nickel-refinery-dust	4.74E-02	3.08E+00	1.23E+03
Air	Nickel-subsulfide	9.48E-02	6.16E+00	2.46E+03
Air	PAH's	1.70E-04	1.10E-02	4.42E+00
Air	particles diesel soot	9.78E-06	6.35E-04	2.54E-01
Air	Polychlorobiphenyls	1.97E-03	1.28E-01	5.12E+01
Air	pentachlorophenol	7.21E-03	4.68E-01	1.87E+02
Air	propyleneoxide	1.17E-05	7.60E-04	3.04E-01
Air	styrene	2.44E-08	1.58E-06	6.34E-04
Air	perchloroethylene	4.82E-07	3.13E-05	1.25E-02
Air	carbontetrachloride	8.38E-04	5.44E-02	2.18E+01
Air	chloroform	2.63E-05	1.71E-03	6.83E-01
Air	vinyl chloride	2.09E-07	1.36E-05	5.43E-03
Water	1,2-dibromoethane	1.24E-03	8.05E-02	3.22E+01
Water	1,2-dichloroethane	2.98E-05	1.94E-03	7.74E-01
Water	1,3-butadiene	3.37E-04	2.19E-02	8.75E+00
Water	1,4-dioxane	9.21E-07	5.98E-05	2.39E-02
Water	2,4,6-trichlorophenol	1.05E-05	6.82E-04	2.73E-01
Water	acetaldehyde	9.23E-07	5.99E-05	2.40E-02
Water	acrylonitrile	4.16E-05	2.70E-03	1.08E+00
Water	alpha-hexachlorocyclohexan	6.85E-03	4.45E-01	1.78E+02
Water	Arsenic	6.57E-02	4.27E+00	1.71E+03
Water	Bis(chloromethyl)ether	1.54E-02	1.00E+00	4.00E+02
Water	benzene	4.12E-06	2.68E-04	1.07E-01
Water	benzo(a)anthracene	6.58E-01	4.27E+01	1.71E+04
Water	benzo(a)pyrene	2.99	1.94E+02	7.77E+04
Water	benzotrichloride	9.46E-03	6.14E-01	2.46E+02
Water	benzylchloride	1.98E-05	1.29E-03	5.14E-01
Water	beta-chlorocyclohexan	5.75E-03	3.73E-01	1.49E+02
Water	bromodichloromethane	9.36E-06	6.08E-04	2.43E-01
Water	Cadmium	7.12E-02	4.62E+00	1.85E+03
Water	Chromium (VI)	3.43E-01	2.23E+01	8.91E+03
Water	di(2-ethylhexyl)phthalate	6.64E-04	4.31E-02	1.72E+01
Water	dibenz(a)anthracene	4.07E+01	2.64E+03	1.06E+06
Water	dichloromethane	4.97E-07	3.23E-05	1.29E-02
Water	Dichlorvos	1.17E-05	7.60E-04	3.04E-01
Water	dioxins (TEQ)	2.02E+03	1.31E+05	5.25E+07
Water	epichloorhydrin	9.90E-07	6.43E-05	2.57E-02
Water	ethylene oxide	1.39E-04	9.03E-03	3.61E+00
Water	formaldehyde	4.97E-06	3.23E-04	1.29E-01
Water	gamma-HCH (Lindane)	4.16E-03	2.70E-01	1.08E+02
Water	hexachlorobenzene	1.25E-01	8.12E+00	3.25E+03
Water	Nickel	3.11E-02	2.02E+00	8.08E+02
Water	Nickel--subsulfide	5.02E-03	3.26E-01	1.30E+02
Water	Nickel-refinery-dust	1.00E-02	6.49E-01	2.60E+02
Water	PAH's	2.60E-03	1.69E-01	6.75E+01
Water	Polychlorobiphenyls	3.91E-02	2.54E+00	1.02E+03
Water	pentachlorophenol	2.29E-02	1.49E+00	5.95E+02
Water	propylene oxide	1.74E-05	1.13E-03	4.52E-01
Water	styrene	1.22E-06	7.92E-05	3.17E-02
Water	perchloroethylene	4,72E-07	3,06E-05	1,23E-02
Water	carbontetrachloride	8.29E-04	5.38E-02	2.15E+01
Water	chloroform	2.60E-05	1.69E-03	6.75E-01
Water	vinyl chloride	2.84E-07	1.84E-05	7.38E-03
Soil	1,2-dibromoethane (ind.)	3.81E-03	2.47E-01	9.90E+01
Soil	1,2-dichloroethane (ind.)	4.58E-04	2.97E-02	1.19E+01
Soil	1,3-butadiene (ind.)	1.20E-05	7.79E-04	3.12E-01
Soil	1,4-dioxane (ind.)	3.10E-07	2.01E-05	8.05E-03
Soil	2,4,6-trichlorophenol (ind.)	2.76E-06	1.79E-04	7.17E-02
Soil	acetaldehyde (ind.)	4.77E-07	3.10E-05	1.24E-02
Soil	acrylonitrile (ind.)	7.01E-05	4.55E-03	1.82E+00
Soil	alpha-hexachlorocyclohexan (agr.)	2.32E-02	1.51E+00	6.03E+02
Soil	Arsenic (ind.)	1.32E-02	8.57E-01	3.43E+02
Soil	Bis(chloromethyl)ether (ind.)	1.68E-02	1.09E+00	4.36E+02
Soil	benzene (ind.)	1.33E-05	8.64E-04	3.45E-01
Soil	benzo(a)anthracene (ind.)	1.60E-01	1.04E+01	4.16E+03
Soil	benzo(a)pyrene (ind.)	2.06E-03	1.34E-01	5.35E+01
Soil	benzotrichloride (ind.)	1.32E-01	8.57E+00	3.43E+03
Soil	benzylchloride (ind.)	4.16E-05	2.70E-03	1.08E+00

Figure 29: Continued

Soil	beta-chlorocyclohexan (agr.)	7.36E-03	4.78E-01	1.91E+02
Soil	bromodichloromethane (ind.)	7.82E-05	5.08E-03	2.03E+00
Soil	Cadmium (ind.)	3.98E-03	2.58E-01	1.03E+02
Soil	Chromium (ind.)	2.71E-01	1.76E+01	7.04E+03
Soil	di(2-ethylhexyl)phthalate(ind)	3.18E-07	2.06E-05	8.26E-03
Soil	dibenz(a)anthracene (ind.)	2.44E+01	1.58E+03	6.34E+05
Soil	dichloromethane (ind.)	5.99E-06	3.89E-04	1.56E-01
Soil	Dichlorvos (agr.)	2.25E-05	1.46E-03	5.84E-01
Soil	2,3,7,8-TCDD Dioxin (ind.)	7.06	4.58E+02	1.83E+05
Soil	epichloorhydrin (ind.)	1.30E-06	8.44E-05	3.38E-02
Soil	ethyleenoxide (ind.)	2.38E-03	1.55E-01	6.18E+01
Soil	formaldehyde (ind.)	1.83E-06	1.19E-04	4.75E-02
Soil	gamma-HCH (Lindane) (agr.)	8.64E-03	5.61E-01	2.24E+02
Soil	hexachlorobenzene (ind.)	1.47E-01	9.55E+00	3.82E+03
Soil	Nickel (ind.)	3.94E-03	2.56E-01	1.02E+02
Soil	Nickel-refinery-dust (ind.)	6.37E-03	4.14E-01	1.65E+02
Soil	Nickel-subsulfide (ind.)	1.27E-02	8.25E-01	3.30E+02
Soil	PCBs (ind.)	2.04E-02	1.32E+00	5.30E+02
Soil	pentachloorfenol (ind.)	1.26E-05	8.18E-04	3.27E-01
Soil	propyleenoxide (ind.)	1.40E-04	9.09E-03	3.64E+00
Soil	styrene (ind.)	2.09E-08	1.36E-06	5.43E-04
Soil	perchloroethylene (ind.)	6.00E-06	3.90E-04	1.56E-01
Soil	carbontetrachloride (ind.)	3.99E-02	2.59E+00	1.04E+03
Soil	chloroform (ind.)	4.12E-06	2.68E-04	1.07E-01
Soil	vinylchloride (ind.)	7.67E-07	4.98E-05	1.99E-02

1.1.2 Respiratory effects on humans caused by organic substances (H,A)

This impact category replaces more or less the summer smog category. Fate analysis is based on empirical data.
All damage factors are expressed per kg emitted substance. The unit of damage is DALYs.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	1,1,1-trichloroethane	1.96E-08	1.27E-06	5.09E-04
Air	1,2,3-trimethyl benzene	2.72E-06	1.77E-04	7.06E-02
Air	1,2,4-trimethyl benzene	2.72E-06	1.77E-04	7.06E-02
Air	1,3,5-trimethyl benzene	2.98E-06	1.94E-04	7.74E-02
Air	1,3-butadiene	1.87E-06	1.21E-04	4.86E-02
Air	1-butene	2.30E-06	1.49E-04	5.97E-02
Air	1-butoxy propanol	9.36E-07	6.08E-05	2.43E-02
Air	1-hexene	1.87E-06	1.21E-04	4.86E-02
Air	1-methoxy 2-propanol	7.91E-07	5.14E-05	2.05E-02
Air	1-pentene	2.13E-06	1.38E-04	5.53E-02
Air	2,2-dimethyl butane	5.19E-07	3.37E-05	1.35E-02
Air	2,3-dimethyl butane	1.19E-06	7.73E-05	3.09E-02
Air	2-butoxy ethanol	9.36E-07	6.08E-05	2.43E-02
Air	2-ethoxy ethanol	8.34E-07	5.42E-05	2.17E-02
Air	2-hexanone	1.19E-06	7.73E-05	3.09E-02
Air	2-methoxy ethanol	6.47E-07	4.20E-05	1.68E-02
Air	2-methyl 1-butanol	8.51E-07	5.53E-05	2.21E-02
Air	2-methyl 1-butene	1.70E-06	1.10E-04	4.42E-02
Air	2-methyl 2-butanol	3.06E-07	1.99E-05	7.95E-03
Air	2-methyl 2-butene	1.79E-06	1.16E-04	4.65E-02
Air	2-methyl hexane	8.51E-07	5.53E-05	2.21E-02
Air	2-methyl pentane	9.36E-07	6.06E-05	2.43E-02
Air	2-pentanone	1.19E-06	7.73E-05	3.09E-02
Air	3,5-diethyl toluene	2.81E-06	1.82E-04	7.30E-02
Air	3,5-dimethyl ethyl benzene	2.81E-06	1.82E-04	7.30E-02
Air	3-hexanone	1.28E-06	8.31E-05	3.32E-02
Air	3-methyl 1-butanol	8.51E-07	5.53E-05	2.21E-02
Air	3-methyl 1-butene	1.45E-06	9.42E-05	3.77E-02
Air	3-methyl 2-butanol	7.91E-07	5.14E-05	2.05E-02
Air	3-methyl hexane	7.83E-07	5.08E-05	2.03E-02
Air	3-methyl pentane	1.02E-06	6.62E-05	2.65E-02
Air	3-pentanol	9.36E-07	6.08E-05	2.43E-02
Air	3-pentanone	8.51E-07	5.53E-05	2.21E-02
Air	acetaldehyde	1.36E-06	8.83E-05	3.53E-02
Air	acetic acid	2.13E-07	1.38E-05	5.53E-03
Air	acetone	2.04E-07	1.32E-05	5.30E-03
Air	propionaldehyde	1.70E-06	1.10E-04	4.42E-02

Air	alcohols	7.60E-07	4.94E-05	1.97E-02
Air	aldehydes	1.40E-06	9.09E-05	3.64E-02
Air	alkanes	7.50E-07	4.87E-05	1.95E-02
Air	alkenes	2.10E-06	1.36E-04	5.45E-02
Air	benzene	4.68E-07	3.04E-05	1.22E-02
Air	butane	7.57E-07	4.92E-05	1.97E-02
Air	butanol	1.36E-06	8.83E-05	3.53E-02
Air	butene	2.47E-06	1.60E-04	6.42E-02
Air	cis 1,2-dichloroethene	9.36E-07	6.08E-05	2.43E-02
Air	cis 2-butene	2.47E-06	1.60E-04	6.42E-02
Air	cis 2-hexene	2.30E-06	1.49E-04	5.97E-02
Air	cis 2-pentene	2.38E-06	1.55E-04	6.18E-02
Air	CxHy aromatic	2.10E-06	1.36E-04	5.45E-02
Air	CxHy chloro	3.50E-07	2.27E-05	9.09E-03
Air	CxHy halogenated	3.50E-07	2.27E-05	9.09E-03
Air	cyclohexane	6.21E-07	4.03E-05	1.61E-02
Air	cyclohexanol	9.36E-07	6.08E-05	2.43E-02
Air	cyclohexanone	6.47E-07	4.20E-05	1.68E-02
Air	decane	8.26E-07	5.36E-05	2.15E-02
Air	di-i-propyl ether	1.02E-06	6.62E-05	2.65E-02
Air	diacetone alcohol	5.62E-07	3.65E-05	1.46E-02
Air	dichloromethane	1.45E-07	9.42E-06	3.77E-03
Air	diethyl ether	1.02E-06	6.62E-05	2.65E-02
Air	dimethyl ether	3.74E-07	2.43E-05	9.71E-03
Air	dodecane	7.66E-07	4.97E-05	1.99E-02
Air	esters	3.70E-07	2.40E-05	9.61E-03
Air	ethane	2.64E-07	1.71E-05	6.86E-03
Air	ethane diol	8.26E-07	5.36E-05	2.15E-02
Air	ethanol	8.34E-07	5.42E-05	2.17E-02
Air	ethene	2.13E-06	1.38E-04	5.53E-02
Air	ethers	7.40E-07	4.81E-05	1.92E-02
Air	ethyl t-butyl ether	4.60E-07	2.99E-05	1.19E-02
Air	ethylacetate	4.60E-07	2.99E-05	1.19E-02
Air	ethylbenzene	1.53E-06	9.94E-05	3.97E-02
Air	acetylene	1.87E-07	1.21E-05	4.86E-03
Air	formaldehyde	1.11E-06	7.21E-05	2.88E-02
Air	formic acid	6.89E-08	4.47E-06	1.79E-03
Air	heptane	1.11E-06	7.21E-05	2.88E-02
Air	hexane	1.02E-06	6.62E-05	2.65E-02
Air	i-butane	6.64E-07	4.31E-05	1.72E-02
Air	i-butanol	8.09E-07	5.25E-05	2.10E-02
Air	i-butyraldehyde	1.11E-06	7.21E-05	2.88E-02
Air	i-pentane	8.51E-07	5.53E-05	2.21E-02
Air	i-propanol	2.98E-07	1.94E-05	7.74E-03
Air	i-propyl acetate	4.60E-07	2.99E-05	1.19E-02
Air	i-propyl benzene	1.11E-06	7.21E-05	2.88E-02
Air	isoprene	2.38E-06	1.55E-04	6.18E-02
Air	ketones	8.70E-07	5.65E-05	2.26E-02
Air	m-ethyl toluene	2.21E-06	1.44E-04	5.74E-02
Air	m-xylene	2.38E-06	1.55E-04	6.18E-02
Air	methane	1.28E-08	8.31E-07	3.32E-04
Air	methanol	2.81E-07	1.82E-05	7.30E-03
Air	methyl acetate	1.02E-07	6.62E-06	2.65E-03
Air	methyl chloride	1.11E-08	7.21E-07	2.88E-04
Air	methyl ethyl ketone	8.09E-07	5.25E-05	2.10E-02
Air	methyl formate	7.15E-08	4.64E-06	1.86E-03
Air	methyl i-butyl ketone	1.02E-06	6.62E-05	2.65E-02
Air	methyl i-propyl ketone	7.83E-07	5.08E-05	2.03E-02
Air	methyl propene	1.36E-06	8.83E-05	3.53E-02
Air	methyl t-butyl ether	3.32E-07	2.16E-05	8.62E-03
Air	methyl t-butyl ketone	6.98E-07	4.53E-05	1.81E-02
Air	n-butanol	1.36E-06	8.83E-05	3.53E-02
Air	n-butyl acetate	5.19E-07	3.37E-05	1.35E-02
Air	n-butyraldehyde	1.70E-06	1.10E-04	4.42E-02
Air	n-propanol	1.19E-06	7.73E-05	3.09E-02
Air	n-propyl acetate	6.21E-07	4.03E-05	1.61E-02
Air	n-propyl benzene	1.36E-06	8.83E-05	3.53E-02
Air	neopentane	3.74E-07	2.43E-05	9.71E-03
Air	NMVOC	1.28E-06	8.31E-05	3.32E-02
Air	nonane	8.51E-07	5.53E-05	2.21E-02
Air	o-ethyl toluene	1.96E-06	1.27E-04	5.09E-02
Air	o-xylene	2.30E-06	1.49E-04	5.97E-02
Air	octane	9.36E-07	6.08E-05	2.43E-02
Air	p-ethyl toluene	1.96E-06	1.27E-04	5.09E-02

Figure 29: Continued

Air	p-xylene	2.21E-06	1.44E-04	5.74E-02
Air	pentanal	1.62E-06	1.05E-04	4.21E-02
Air	pentane	8.51E-07	5.53E-05	2.21E-02
Air	propane	3.83E-07	2.49E-05	9.95E-03
Air	propane diol	1.02E-06	6.62E-05	2.65E-02
Air	propene	2.38E-06	1.55E-04	6.18E-02
Air	propanoic acide	3.23E-07	2.10E-05	8.39E-03
Air	s-butanol	8.51E-07	5.53E-05	2.21E-02
Air	s-butyl acetate	5.79E-07	3.76E-05	1.50E-02
Air	t-butanol	2.64E-07	1.71E-05	6.86E-03
Air	t-butyl acetate	1.36E-07	8.83E-06	3.53E-03
Air	perchloroethylene	6.21E-08	4.03E-06	1.61E-03
Air	toluene	1.36E-06	8.83E-05	3.53E-02
Air	trans 1,2-dichloroethene	8.43E-07	5.47E-05	2.19E-02
Air	trans 2-butene	2.47E-06	1.60E-04	6.42E-02
Air	trans 2-hexene	2.30E-06	1.49E-04	5.97E-02
Air	trans 2-pentene	2.38E-06	1.55E-04	6.18E-02
Air	trichloroethylene	6.98E-07	4.53E-05	1.81E-02
Air	chloroform	4.94E-08	3.21E-06	1.28E-03
Air	undecane	8.26E-07	5.36E-05	2.16E-02
Air	VOC	6.46E-07	4.19E-05	1.68E-02
Air	xylene	2.21E-06	1.44E-04	5.74E-02

1.1.3 Respiratory effects on humans caused by inorganic substances (H,A)

This impact category replaces more or less the winter smog category.
Fate analysis is based on empirical data.
All damage factors are expressed per kg emission. The unit of damage is DALYs.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	ammonia	8.50E-05	5.52E-03	2.21E+00
Air	dust (PM10)	3.75E-04	2.44E-02	9.74E+00
Air	dust (PM2.5)	7.00E-04	4.55E-02	1.82E+01
Air	TSP	1.10E-04	7.14E-03	2.86E+00
Air	NO	1.37E-04	8.90E-03	3.56E+00
Air	NO2	8.87E-05	5.76E-03	2.30E+00
Air	NOx	8.87E-05	5.76E-03	2.30E+00
Air	NOx (as NO2)	8.87E-05	5.76E-03	2.30E+00
Air	SO2	5.46E-05	3.55E-03	1.42E+00
Air	SO3	4.37E-05	2.84E-03	1.14E+00
Air	SOx	5.46E-05	3.55E-03	1.42E+00
Air	SOx (as SO2)	5.46E-05	3.55E-03	1.42E+00

1.1.4 Damages to human health caused by climate change (H,A)

Damage calculation was performed over a time scale of 200 years.
The IPCC equivalence factors have been modified. As damage is not linear dependent on the atmospheric lifetime, a separate damage calculation is made for CO2, CH4 en CH4:

- Gasses with an atmospheric lifetime below 20 years are assumed to behave like methane
- Gasses with an atmospheric lifetime between 20 and 100 years behave like CO2
- Gasses with an atmospheric lifetime oh more than 100 years are assumed to behave like N2O

This means that the IPCC equivalency factor table is split in three groups.
All damage factors are expressed per kg substance. The unit of damage is DALYs.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	methyl chloroform	-4.3E-05	-2.79E-03	-1.12E+00
Air	perfluorethane	2.00E-03	1.30E-01	5.19E+01
Air	trifluoroiodomethane	2.10E-07	1.36E-05	5.45E-03
Air	perfluormethane	1.40E-03	9.09E-02	3.64E+01
Air	CFC-11	2.20E-04	1.43E-02	5.71E+00
Air	CFC-113	6.30E-04	4.09E-02	1.64E+01
Air	CFC-12	1.40E-03	9.09E-02	3.64E+01
Air	carbon dioxide	2.10E-07	1.36E-05	5.45E-03
Air	methylene chloride	1.90E-06	1.23E-04	4.94E-02
Air	HALON-1301	-7.10E-03	-4.61E-01	-1.84E+02
Air	HCFC-123	6.60E-06	4.29E-04	1.71E-01
Air	HCFC-124	8.50E-05	5.52E-03	2.21E+00
Air	HCFC-141b	5.20E-05	3.38E-03	1.35E+00
Air	HCFC-142b	3.40E-04	2.21E-02	8.83E+00
Air	HCFC-22	2.80E-04	1.82E-02	7.27E+00
Air	HFC-125	5.70E-04	3.70E-02	1.48E+01
Air	HFC-134	2.10E-04	1.36E-02	5.45E+00
Air	HFC-134a	2.70E-04	1.75E-02	7.01E+00
Air	HFC-143	6.30E-05	4.09E-03	1.64E+00
Air	HFC-143a	7.80E-04	5.06E-02	2.03E+01
Air	HFC-152a	2.90E-05	1.88E-03	7.53E-01
Air	HFC-227ea	5.90E-04	3.83E-02	1.53E+01
Air	HFC-23	2.60E-03	1.69E-01	6.75E+01
Air	HFC-236fa	1.40E-03	9.09E-02	3.64E+01
Air	HFC-245ca	1.20E-04	7.79E-03	3.12E+00
Air	HFC-32	1.40E-04	9.09E-03	3.64E+00
Air	HFC-41	3.10E-05	2.01E-03	8.05E-01
Air	HFC-4310mee	2.70E-04	1.75E-02	7.01E+00
Air	methane	4.40E-06	2.86E-04	1.14E-01
Air	nitrous oxide	6.90E-05	4.48E-03	1.79E+00
Air	perfluorbutane	1.50E-03	9.74E-02	3.90E+01
Air	perfluorcyclobutane	1.90E-03	1.23E-01	4.94E+01
Air	perfluorhexane	1.60E-03	1.04E-01	4.16E+01
Air	perfluorpentane	1.70E-03	1.10E-01	4.42E+01
Air	perfluorpropane	1.50E-03	9.74E-02	3.90E+01
Air	sulphur hexafluoride	5.30E-03	3.44E-01	1.38E+02
Air	carbontetrachloride	-2.60E-04	-1.69E-02	-6.75E+00
Air	chloroform	8.30E-07	5.39E-05	2.16E-02

1.1.5 Human health effects caused by ionising radiation (H,A)

Fate-, and exposure models are based on studies for the French nuclear industry. All damage factors are based on a release of 1 Bequerel (Bq). The unit of damage is DALYs.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	C-14	2.10E-10	1.36E-08	5.45E-06
Air	Co-58	4.30E-13	2.79E-11	1.12E-08
Air	Co-60	1.60E-11	1.04E-09	4.16E-07
Air	Cs-134	1.20E-11	7.79E-10	3.12E-07
Air	Cs-137	1.30E-11	8.44E-10	3.38E-07
Air	H-3	1.40E-14	9.09E-13	3.64E-10
Air	I-129	9.40E-10	6.10E-08	2.44E-05
Air	I-131	1.60E-13	1.04E-11	4.16E-09
Air	I-133	9.40E-15	6.10E-13	2.44E-10
Air	Kr-85	1.40E-16	9.09E-15	3.64E-12
Air	Pb-210	1.50E-12	9.74E-11	3.90E-08
Air	Po-210	1.50E-12	9.74E-11	3.90E-08
Air	Pu alpha	8.30E-11	5.39E-09	2.16E-06
Air	Pu-238	6.70E-11	4.35E-09	1.74E-06
Air	Ra-226	9.10E-13	5.91E-11	2.36E-08
Air	Rn-222	2.40E-14	1.56E-12	6.23E-10
Air	Th-230	4.50E-11	2.92E-09	1.17E-06
Air	U-234	9.70E-11	6.30E-09	2.52E-06
Air	U-235	2.10E-11	1.36E-09	5.45E-07
Air	U-238	8.20E-12	5.32E-10	2.13E-07
Air	Xe-133	1.40E-16	9.09E-15	3.64E-12
Water	Ag-110m	5.10E-13	3.31E-11	1.32E-08
Water	Co-58	4.10E-14	2.66E-12	1.06E-09
Water	Co-60	4.40E-11	2.86E-09	1.14E-06
Water	Cs-134	1.40E-10	9.09E-09	3.64E-06
Water	Cs-137	1.70E-10	1.10E-08	4.42E-06
Water	H-3	4.50E-16	2.92E-14	1.17E-11

Figure 29: Continued

Water	I-131	5.00E-13	3.25E-11	1.30E-08
Water	Mn-54	3.10E-13	2.01E-11	8.05E-09
Water	Ra-226	1.30E-13	8.44E-12	3.38E-09
Water	Sb-124	8.20E-13	5.32E-11	2.13E-08
Water	U-234	2.40E-12	1.56E-10	6.23E-08
Water	U-235	2.30E-12	1.49E-10	5.97E-08
Water	U-238	2.30E-12	1.49E-10	5.97E-08

1.1.6 Human health effects caused by ozone layer depletion (H,A)

All damage factors are expressed per kg release. The unit of damage is DALYs.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	1,1,1-trichloroethane	1.26E-04	8.18E-03	3.27E+00
Air	CFC-11	1.05E-03	6.82E-02	2.73E+01
Air	CFC-113	9.48E-04	6.16E-02	2.46E+01
Air	CFC-114	8.95E-04	5.81E-02	2.32E+01
Air	CFC-115	4.21E-04	2.73E-02	1.09E+01
Air	CFC-12	8.63E-04	5.60E-02	2.24E+01
Air	HALON-1201	1.47E-03	9.55E-02	3.82E+01
Air	HALON-1202	1.32E-03	8.57E-02	3.43E+01
Air	HALON-1211	5.37E-03	3.49E-01	1.39E+02
Air	HALON-1301	1.26E-02	8.18E-01	3.27E+02
Air	HALON-2311	1.47E-04	9.55E-03	3.82E+00
Air	HALON-2401	2.63E-04	1.71E-02	6.83E+00
Air	HALON-2402	7.37E-03	4.79E-01	1.91E+02
Air	HCFC-123	1.47E-05	9.55E-04	3.82E-01
Air	HCFC-124	3.16E-05	2.05E-03	8.21E-01
Air	HCFC-141b	1.05E-04	6.82E-03	2.73E+00
Air	HCFC-142b	5.26E-05	3.42E-03	1.37E+00
Air	HCFC-22	4.21E-05	2.73E-03	1.09E+00
Air	HCFC-225ca	2.11E-05	1.37E-03	5.48E-01
Air	HCFC-225cb	2.11E-05	1.37E-03	5.48E-01
Air	methyl bromide	6.74E-04	4.38E-02	1.75E+01
Air	methyl chloride	2.11E-05	1.37E-03	5.48E-01
Air	carbontetrachloride	1.26E-03	8.18E-02	3.27E+01

1.2 Damage category Ecosystem Quality (H,A)

The Ecosystem Quality damages are specified as PDF*m^2*yr. PDF is short for Potentially Disappeared Fraction of Species. A damage of one means all species disappear from one m^2 during one year, or 10% of all species disappear from 10 m^2 during one year, or 10% of all species disappear from 1 m^2 during 10 years. Within the damage category Ecosystem Quality, special care is needed to avoid double counting when land-use is modelled. See the remarks under these damage categories.

1.2.1 Damage to Ecosystem Quality caused by ecotoxic emissions (H,A)

Fate analysis was done in EUSES. Pesticides that evaporate during application must be counted as air emissions. Pesticides that are accidentally sprayed in surface waters must be counted as water emissions. The remainder must be counted as soil emissions. The damage from pesticides in the agricultural soil as such (root zone) was deliberately excluded to avoid double counting with land-use. This means the damage factors in this list are based on secondary (leaching) emissions from the soil into surface and ground water and evaporation.

All damage factors are expressed per kg release. The unit of damage is PDF*m^2*yr.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	1,2,3-trichlorobenzene	3.51E-02	6.84E-06	2.74E-03
Air	1,2,4-trichlorobenzene	2.54E-02	4.95E-06	1.98E-03
Air	1,3,5-trichlorobenzene	1.29E-01	2.51E-05	1.01E-02
Air	2,4-D	1.46E+00	2.85E-04	1.14E-01
Air	Arsenic	5.92E+02	1.15E-01	4.62E+01
Air	Atrazine	2.09E+02	4.07E-02	1.63E+01
Air	Azinphos-methyl	1.10E+04	2.14E+00	8.58E+02
Air	Bentazon	7.33E+00	1.43E-03	5.72E-01
Air	benzene	2.75E-03	5.36E-07	2.14E-04
Air	benzo(a)pyrene	1.42E+02	2.77E-02	1.11E+01
Air	Carbendazim	2.40E+03	4.68E-01	1.87E+02
Air	Cadmium	9.65E+03	1.88E+00	7.52E+02
Air	Chromium	4.13E+03	8.05E-01	3.22E+02
Air	Copper	1.46E+03	2.85E-01	1.14E+02
Air	di(2-ethylhexyl)phthalate	1.94E-03	3.78E-07	1.51E-04
Air	dibutylphthalate	1.13E-01	2.20E-05	8.81E-03
Air	Dichlorvos	1.61E+00	3.14E-04	1.26E-01
Air	2,3,7,8-TCDD Dioxin	1.32E+05	2.57E+01	1.03E+04
Air	Diquat-dibromide	2.39E+03	4.66E-01	1.86E+02
Air	Diuron	4.43E+03	8.64E-01	3.45E+02
Air	DNOC	8.19E+00	1.60E-03	6.39E-01
Air	fentin acetate	6.77E+02	1.32E-01	5.28E+01
Air	fluoranthene	4.37E-02	8.52E-06	3.41E-03
Air	gamma-HCH (Lindane)	2.16E+00	4.21E-04	1.68E-01
Air	Hexachlorobenzene	3.88E+01	7.56E-03	3.03E+00
Air	Mercury	8.29E+02	1.62E-01	6.46E+01
Air	Malathion	1.17E+02	2.28E-02	9.12E+00
Air	Maneb	3.84E+01	7.49E-03	2.99E+00
Air	Mecoprop	7.79E-02	1.52E-05	6.07E-03
Air	Metabenzthiazuron	3.07E+02	5.98E-02	2.39E+01
Air	metals	2.60E+02	5.07E-02	2.03E+01
Air	Metamitron	3.78E+01	7.37E-03	2.95E+00
Air	Metribuzin	4.92E+02	9.59E-02	3.84E+01
Air	Mevinphos	2.13E+03	4.15E-01	1.66E+02
Air	Monolinuron	1.06E+02	2.07E-02	8.27E+00
Air	Nickel	7.10E+03	1.38E+00	5.54E+02
Air	PAH's	7.80E-04	1.52E-07	6.08E-05
Air	Parathion	6.05E+01	1.18E-02	4.72E+00
Air	Lead	2.54E+03	4.95E-01	1.98E+02
Air	Polychlorobiphenyls	8.07E+01	1.57E-02	6.29E+00
Air	pentachlorophenol	1.33E+01	2.59E-03	1.04E+00
Air	Simazine	1.44E+03	2.81E-01	1.12E+02
Air	Thiram	2.26E+02	4.41E-02	1.76E+01
Air	toluene	2.40E-04	4.68E-08	1.87E-05
Air	Trifluralin	1.09E+00	2.12E-04	8.50E-02
Air	Zinc	2.89E+03	5.63E-01	2.25E+02
Water	1,2,3-trichlorobenzene	1.56E-01	3.04E-05	1.22E-02
Water	1,2,4-trichlorobenzene	1.39E-01	2.71E-05	1.08E-02
Water	1,3,5-trichlorobenzene	2.73E-01	5.32E-05	2.13E-02
Water	2,4-D	7.56E-02	1.47E-05	5.89E-03
Water	Arsenic	1.14E+01	2.22E-03	8.89E-01
Water	Atrazine	5.06E+01	9.86E-03	3.95E+00
Water	Azinphos-methyl	8.87E+02	1.73E-01	6.92E+01
Water	Bentazon	5.81E-02	1.13E-05	4.53E-03
Water	benzene	4.80E-02	9.36E-06	3.74E-03
Water	benzo(a)pyrene	3.68E+01	7.17E-03	2.87E+00
Water	Carbendazim	1.63E+02	3.18E-02	1.27E+01
Water	Cadmium	4.80E+02	9.36E-02	3.74E+01
Water	Chromium	6.87E+01	1.34E-02	5.36E+00
Water	Copper	1.47E+02	2.87E-02	1.15E+01
Water	di(2-ethylhexyl)phthalate	6.37E-01	1.24E-04	4.97E-02
Water	dibutylphthalate	1.62E+00	3.16E-04	1.26E-01
Water	Dichlorvos	1.81E-01	3.53E-05	1.41E-02
Water	dioxins (TEQ)	1.87E+05	3.65E+01	1.46E+04
Water	Diquat-dibromide	1.18E+02	2.30E-02	9.20E+00
Water	Diuron	2.31E+02	4.50E-02	1.80E+01
Water	DNOC	6.73E-01	1.31E-04	5.25E-02
Water	fentin acetate	7.85E+02	1.53E-01	6.12E+01
Water	fluoranthene	3.96E+00	7.72E-04	3.09E-01
Water	gamma-HCH (Lindane)	1.04E+01	2.03E-03	8.11E-01
Water	hexachlorobenzene	4.55E+01	8.87E-03	3.55E+00

Figure 29: Continued

Water	Mercury	1.97E+02	3.84E-02	1.54E+01
Water	Malathion	1.64E+02	3.20E-02	1.28E+01
Water	Maneb	6.23E-01	1.21E-04	4.86E-02
Water	Mecoprop	1.35E-02	2.63E-06	1.05E-03
Water	Metabenzthiazuron	1.43E+01	2.79E-03	1.12E+00
Water	Metamitron	3.77E-01	7.35E-05	2.94E-02
Water	Metribuzin	3.18E+00	6.20E-04	2.48E-01
Water	Mevinphos	6.73E+01	1.31E-02	5.25E+00
Water	Monolinuron	1.04E+01	2.03E-03	8.11E-01
Water	Nickel	1.43E+02	2.79E-02	1.12E+01
Water	PAH's	2.10E-03	4.09E-07	1.64E-04
Water	Parathion	2.48E+02	4.83E-02	1.93E+01
Water	Lead	7.39E+00	1.44E-03	5.76E-01
Water	Polychlorobiphenyls	2.58E+02	5.03E-02	2.01E+01
Water	pentachlorophenol	2.51E+01	4.89E-03	1.96E+00
Water	Simazine	6.03E+01	1.18E-02	4.70E+00
Water	Thiram	8.74E+02	1.70E-01	6.81E+01
Water	toluene	1.73E-01	3.37E-05	1.35E-02
Water	Trifluralin	7.80E+01	1.52E-02	6.08E+00
Water	Zinc	1.63E+01	3.18E-03	1.27E+00
Soil	1,2,3-trichlorobenzene (ind.)	2.41E+00	4.70E-04	1.88E-01
Soil	1,2,4-trichlorobenzene (ind.)	2.26E+00	4.41E-04	1.76E-01
Soil	1,3,5-trichlorobenzene (ind.)	1.19E+00	2.32E-04	9.28E-02
Soil	2,4-D (agr.)	1.27E-04	2.48E-08	9.90E-06
Soil	Arsenic (ind.)	6.10E+02	1.19E-01	4.76E+01
Soil	Atrazine (agr.)	1.49E-01	2.90E-05	1.16E-02
Soil	Azinphos-methyl (agr.)	3.55E-01	6.92E-05	2.77E-02
Soil	Bentazon (agr.)	1.66E-02	3.24E-06	1.29E-03
Soil	benzene (ind.)	4.97E-01	9.69E-05	3.88E-02
Soil	benzo(a)pyrene (ind.)	7.25E+03	1.41E+00	5.65E+02
Soil	Carbendazim (agr.)	2.34E+00	4.56E-04	1.82E-01
Soil	Cadmium (agr.)	3.01E+01	5.87E-03	2.35E+00
Soil	Cadmium (ind.)	9.94E+03	1.94E+00	7.75E+02
Soil	Chromium (ind.)	4.24E+03	8.27E-01	3.31E+02
Soil	Copper (ind.)	1.50E+03	2.92E-01	1.17E+02
Soil	di(2-ethylhexyl)phthalate(ind)	2.67E-02	5.20E-06	2.08E-03
Soil	dibutylphthalate (ind.)	1.14E+00	2.22E-04	8.89E-02
Soil	Dichlorvos (agr.)	7.52E-04	1.47E-07	5.86E-05
Soil	2,3,7,8-TCDD Dioxin (ind.)	2.09E+05	4.07E+01	1.63E+04
Soil	Diquat-dibromide (agr.)	6.84E-02	1.33E-05	5.33E-03
Soil	Diuron (agr.)	4.07E-02	7.93E-06	3.17E-03
Soil	DNOC (agr.)	6.17E-03	1.20E-06	4.81E-04
Soil	fentin acetate (agr.)	3.84E-01	7.49E-05	2.99E-02
Soil	fluoranthene (ind.)	8.00E+00	1.56E-03	6.24E-01
Soil	gamma-HCH (Lindane) (agr.)	1.38E+00	2.69E-04	1.08E-01
Soil	hexachlorobenzene (ind.)	9.96E+01	1.94E-02	7.77E+00
Soil	Mercury (ind.)	1.68E+03	3.27E-01	1.31E+02
Soil	Malathion (agr.)	2.79E-02	5.44E-06	2.18E-03
Soil	Maneb (agr.)	2.61E-01	5.09E-05	2.04E-02
Soil	Mecoprop (agr.)	2.79E-06	5.44E-10	2.18E-07
Soil	Metabenzthiazuron (agr.)	3.15E-01	6.14E-05	2.46E-02
Soil	Metamitron (agr.)	2.03E-04	3.96E-08	1.58E-05
Soil	Metribuzin (agr.)	4.91E-02	9.57E-06	3.83E-03
Soil	Mevinphos (agr.)	2.09E-01	4.07E-05	1.63E-02
Soil	Monolinuron (agr.)	4.38E-01	8.54E-05	3.42E-02
Soil	Nickel (ind.)	7.32E+03	1.43E+00	5.71E+02
Soil	Parathion (agr.)	3.24E-02	6.32E-06	2.53E-03
Soil	Lead (ind.)	1.29E+01	2.51E-03	1.01E+00
Soil	PCBs (ind.)	8.35E+02	1.63E-01	6.51E+01
Soil	pentachloorfenol (ind.)	2.51E+01	4.89E-03	1.96E+00
Soil	Simazine (agr.)	3.87E-01	7.54E-05	3.02E-02
Soil	Thiram (agr.)	9.96E-01	1.94E-04	7.77E-02
Soil	toluene (ind.)	6.79E-02	1.32E-05	5.29E-03
Soil	Trifluralin (agr.)	2.07E-02	4.04E-06	1.61E-03
Soil	Zinc (ind.)	2.98E+03	5.81E-01	2.32E+02

1.2.2 Damage to Ecosystem Quality caused by the combined effect of acidification and eutrophication (H,A)

Unfortunately no damage factors for emissions to water and soil could yet be calculated. We suggest to use the damage factors for air as a temporary, but crude solution.
The damage caused by fertilisers that are deliberately applied on agricultural soil is already included in the land-use damage factors, and should not be treated as an emission leading to eutrophication. The fertilisers that evaporate, or that are accidentally sprayed in surface waters should be counted as an emission.

All damage factors are based on kg emissions to air. The unit of damage is PDF*m^2*yr.

Com-part-ment	Substances	Damage factor	Normalised damage factor	Weighted damage factor
Air	ammonia	15,57	3,04E-03	1,21E+00
Air	NO	8,789	1,71E-03	6,85E-01
Air	NO2	5,713	1,11E-03	4,45E-01
Air	NOx	5,713	1,11E-03	4,45E-01
Air	NOx (as NO2)	5,713	1,11E-03	4,45E-01
Air	SO2	1,041	2,03E-04	8,12E-02
Air	SO3	0,8323	1,62E-04	6,49E-02
Air	SOx	1,041	2.03E-04	8.12E-02
Air	SOx (as SO2)	1,041	2,03E-04	8,12E-02

1.2.3 Damage to Ecosystem Quality caused by land occupation and land conversion (H,A)

It is important to separate two cases:
- Land occupation
- Land conversion

The damage factors for occupation are per area [m^2] times the duration of the occupation [yr]. The effect of restoration of the area type to it's natural condition is not included here, but in the land conversion damage factors. Occupation is seen as a damage, because the area is prevented from restoring to its natural area. Typical examples of land occupation are:
Building new houses in an existing urban area, using a factory in an industrial area, agricultural production in an existing agricultural area. In most cases land is used that has already been converted long ago. In such cases conversion should not be considered.

The damage factors for conversions are per area [m^2]. Conversion factors should only be used if it is clear that a process results in the conversion of one area type into another. Examples are: mining operations in natural areas, expanding agricultural areas at the expense of natural areas, and dumping waste. The difference with the factors for occupation is the inclusion of a restoration time that has been set to 30 years as default. Other restoration times can be easily calculated by dividing the damage factors by 30 and multiplying them with the intended restoration time.

Conversions between agricultural and urban area types can also be modelled by subtracting the damage factors, but, as the damage factors can have considerable uncertainties, the result is unreliable. We suggest to use conversion data only for cases where natural areas are converted into non-natural area types.

1.2.3.1 COMPATIBILITY WITH ESU DATABASE

The ESU database, produced at the ETH Zurich, is one of the few large databases that has consistently included land-use data. Unfortunately no distinction is made between conversion and occupation, the two are always combined. This means a restoration time is always included, and this restoration time cannot be separated in a elegant way. In order to be able to use this large database damage factors: land-use II-III, land use II-IV,

Figure 29: Continued

land-use III-IV and land-use IV-IV have been estimated using the following (rather crude) assumptions:

- *ESU land-use type II can be interpreted as near to natural area*
- *ESU land-use type III can be interpreted as green urban or rail areas. These are the not very intensively used areas*
- *ESU land-use type IV can be interpreted as continuos urban land*
- *ESU assumes a 5 year restoration time between type IV and III. In many cases an occupation time for industrial activities of 25 or 30 years is used. As a result the restoration time results in an overestimation of 20% for land-use II-IV. In the figure presented here the damage factor is thus lowered by 20%.*
- *After the conversion from Land-use II-IV the ESU database uses the factors II-III for the restoration time between type II and III. As we do not want to include these, in general they should be omitted. Unfortunately for processes like the production of hydropower this class is used in a different way and should thus be included*

Using the ESU database is thus not very straightforward, but with the factors presented here a reasonable first order approximation can be obtained, except for instance for processes that involve agricultural production and hydropower.

1.2.3.2 DOUBLE COUNTING

The damage factors are based on empirical observations of the number of plant species per area type. In such observations all effects of the area type are included. This means that also the effects of emissions are included. To avoid double counting these emissions, please observe the guidelines for pesticides and eutrophication.

The unit of damage of land occupation is PDF*m^2*yr.

Land-occupation	Damage factor	Normalised damage factor	Weighted damage factor
land use II-III	0.51	9.94E-05	3.98E-02
land use II-IV	0.96	1.87E-04	7.49E-02
land use III-IV	0.96	1.87E-04	7.49E-02
land use IV-IV	1.15	2.24E-04	8.97E-02
Occup. as Contin. urban land	1.15	2.24E-04	8.97E-02
Occup. as Convent. arable land	1.15	2.24E-04	8.97E-02
Occup. as Discont. urban land	0.96	1.87E-04	7.49E-02
Occup. as Forest land	0.11	2.14E-05	8.58E-03
Occup. as Green urban land	0.84	1.64E-04	6.55E-02
Occup. as Industrial area	0.84	1.64E-04	6.55E-02
Occup. as Intens. meadow land	1.13	2.20E-04	8.81E-02
Occup. as Organic arable land	1.09	2.12E-04	8.50E-02
Occup. as organic meadow land	1.02	1.99E-04	7.95E-02
Occup. as rail/ road area	0.84	1.64E-04	6.55E-02
Occup. as Integrated arable land	1.15	2.24E-04	8.97E-02
Occup. as less intens.meadow land	1.02	1.99E-04	7.95E-02

The unit of damage of land conversion is PDF*m^2.

Land conversion	Damage factor	Normalised damage factor	Weighted damage factor
Conv. to Continuous urban land	34.53	6.73E-03	2.69E+00
Conv. to Convent. arable land	34.38	6.70E-03	2.68E+00
Conv. to Discontinuous urban	28.73	5.60E-03	2.24E+00
Conv. to Green urban	25.16	4.90E-03	1.96E+00
Conv. to Industrial area	25.16	4.90E-03	1.96E+00
Conv. to Integr. arable land	34.38	6.70E-03	2.68E+00
Conv. to Intensive meadow	34.02	6.63E-03	2.65E+00
Conv. to Less intensive meadow	30.62	5.97E-03	2.39E+00
Conv. to Organic arable land	32.73	6.38E-03	2.55E+00
Conv. to Organic meadow	30.62	5.97E-03	2.39E+00
Conv. to rail/ road area	25.16	4.90E-03	1.96E+00

1.3 Damage category Resources (H,A)

The damages to resources are specified as MJ surplus energy. A damage of 1 means that due to a certain extraction further extraction of this resources in the future will require one additional MJ of energy, due to the lower resource concentration, or other unfavourable characteristics of the remaining reserves. The point in future has been chosen as the time at which 5 times the cumulative extraction of the resource before 1990 is extracted. The factor 5 is chosen arbitrarily, but after normalisation this has no further significance.

1.3.1 Damage to Resources caused by extraction of minerals (H,A)

The damage factors are expressed per kg of extracted metal or ore:

- "in ore" refers to the metal content in the ore, so 1kg iron (in ore) means one kg of pure iron
- "ore" refers to the ore. An average metal content is assumed to calculate these figures.

The unit of damage is MJ surplus energy per kg extracted material.

Minerals	Damage factor	Normalised damage factor	Weighted damage factor
aluminium (in ore)	2.38	2.83E-04	5.66E-02
bauxite	0.5	5.95E-05	1.19E-02
chromium (in ore)	0.9165	1.09E-04	2.18E-02
chromium (ore)	0.275	3.27E-05	6.54E-03
copper (in ore)	36.7	4.36E-03	8.73E-01
copper (ore)	0.415	4.93E-05	9.87E-03
iron (in ore)	0.051	6.06E-06	1.21E-03
iron (ore)	0.029	3.45E-06	6.90E-04
lead (in ore)	7.35	8.74E-04	1.75E-01
lead (ore)	0.368	4.38E-05	8.75E-03
manganese (in ore)	0.313	3.72E-05	7.44E-03
manganese (ore)	0.141	1.68E-05	3.35E-03
mercury (in ore)	165.5	1.97E-02	3.94E+00
molybdene (in ore)	41	4.88E-03	9.75E-01
molybdenum (ore)	0.041	4.88E-06	9.75E-04
nickel (in ore)	16.32	1.94E-03	3.88E-01
nickel (ore)	0.245	2.91E-05	5.83E-03
tin (in ore)	600	7.13E-02	1.43E+01
tin (ore)	0.06	7.13E-06	1.43E-03
tungsten (ore)	0.323	3.84E-05	7.68E-03
zinc (in ore)	1.885	2.24E-04	4.48E-02
zinc (ore)	0.075	8.92E-06	1.78E-03

1.3.2 Damage to Resources caused by extraction of fossil fuels (H,A)

The damage factors are expressing MJ surplus energy per kg of extracted fuel, or per m^3 of extracted gas, or per MJ extracted energy.

The unit of damage is MJ surplus energy.

Figure 29: Continued

Fossil fuels	Unit	Damage factor	Normalised damage factor	Weighted damage factor
coal	kg	0.252	3.00E-05	5.99E-03
coal ETH	kg	0.155	1.84E-05	3.69E-03
crude gas	kg	4.2	4.99E-04	9.99E-02
crude oil	kg	5.9	7.02E-04	1.40E-01
crude oil (feedstock)	kg	5.9	7.02E-04	1.40E-01
crude oil (resource)	MJ	1.44E-01	1.71E-05	3.42E-03
crude oil ETH	kg	6.13	7.29E-04	1.46E-01
crude oil IDEMAT	kg	6.15	7.31E-04	1.46E-01
energy from coal	MJ	8.59E-03	1.02E-06	2.04E-04
energy from natural gas	MJ	1.50E-01	1.78E-05	3.57E-03
energy from oil	MJ	0.144	1.71E-05	3.42E-03
hard coal (resource)	MJ	8.59E-03	1.02E-06	2.04E-04
natural gas	kg	4.55	5.41E-04	1.08E-01
natural gas (feedstock)	m3	5.25	6.24E-04	1.25E-01
natural gas (resource)	MJ	1.50E-01	1.78E-05	3.57E-03
natural gas (vol)	m3	5.49	6.53E-04	1.31E-01
natural gas ETH	m3	5.25	6.24E-04	1.25E-01
oil	kg	6.05	7.19E-04	1.44E-01

The energy content of the fuels listed above are:

Energy Content of Fossil fuels		[MJ / unit]
natural gas ETH	35	MJ / m3
crude oil IDEMAT	42.7	MJ / kg
coal ETH	18	MJ / kg
natural gas (feedstock)	35	MJ / m3
crude oil (feedstock)	41	MJ / kg
crude oil ETH	42.6	MJ / kg
natural gas (vol)	36.6	MJ / m3
coal	29.3	MJ / kg
crude oil	41	MJ / kg
natural gas	30.3	MJ / kg
oil	42	MJ / kg
crude gas	28	MJ / kg

APPENDIX G

Drying machine center emissions comparison for manufacturing MSF of plywood 3/8" basis in the PNW: WESP versus no WESP.

		WESP		No WESP	
Substance:	Category:	Emissions / MSF:	Unit:	Emission / MSF:	Unit:
1,2,4-trichlorobenzene	Air	5.26E+03	mg	5.36E+03	mg
1,2-dichloroethane	Air	2.88E+03	mg	2.93E+03	mg
acetaldehyde	Air	1.28E+04	mg	1.28E+04	mg
acetone	Air	8.70E+03	mg	1.27E+04	mg
Acid as H+*	Water	1.50E+03	ng	1.50E+03	ng
acrolein	Air	5.31E+03	mg	3.95E+03	mg
aldehydes	Air	6.07E+03	mg	6.17E+03	mg
alkenes	Air	5.20E+05	mg	4.93E+05	mg
ammonia	Air	1.02E+04	µg	9.66E+03	µg
As	Air	6.02E+03	µg	6.02E+03	µg
B*	Water	4.69E+04	µg	4.24E+04	µg
Ba*	Air	2.96E+05	µg	2.96E+05	µg
Be*	Air	2.67E+04	ng	2.63E+04	ng
benzene	Air	2.50E+03	mg	2.20E+03	mg
BOD*	Water	5.62E+02	mg	5.62E+02	mg
Ca*	Water	6.07E+02	µg	5.11E+02	µg
Cd	Water	2.56E+04	µg	2.56E+04	µg
Cd	Air	1.62E+05	ng	1.62E+05	ng
chromate*	Water	5.72E+04	ng	5.67E+04	ng
Cl-*	Water	2.56E+04	mg	2.56E+04	mg
Cl2*	Air	5.26E+02	mg	5.26E+02	mg
CO*	Air	9.82E+02	g	9.82E+02	g
CO2	Air	1.41E+05	g	1.41E+05	g
CO2 (fossil)	Air	2.90E+04	g	2.88E+04	g
CO2 (non-fossil)	Air	6.53E+03	mg	6.43E+03	mg
coal	Raw	1.36E+05	g	1.36E+05	g
cobalt*	Air	7.29E+04	ng	7.08E+04	ng
COD*	Water	7.94E+03	mg	7.94E+03	mg
Cr	Water	2.56E+04	µg	2.56E+04	µg
Cr	Air	3.66E+03	µg	3.65E+03	µg
crude oil	Raw	2.35E+03	g	2.35E+03	g
CxHy aromatic	Air	1.47E+05	mg	1.50E+05	mg
CxHy chloro	Air	5.97E+03	mg	4.25E+03	mg
cyanide*	Water	3.84E+04	ng	3.84E+04	ng
dichloromethane	Air	2.45E+03	mg	2.51E+03	mg
dioxin (TEQ)	Air	8.25E+01	pg	7.24E+01	pg
dissolved solids*	Water	5.67E+02	g	5.67E+02	g
energy from hydro power*	Raw	1.45E+05	kJ	1.20E+05	kJ

*Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	WESP Emissions / MSF:	Unit:	No WESP Emissions / MSF:	Unit:
Fe*	Air	2.96E+05	µg	2.96E+05	µg
Fe*	Water	6.43E+04	µg	5.57E+04	µg
fluoride ions*	Water	2.82E+03	µg	2.35E+03	µg
formaldehyde	Air	6.68E+03	mg	1.26E+04	mg
H2SO4*	Water	1.17E+04	µg	1.06E+04	µg
HCl*	Air	7.69E+04	µg	6.78E+04	µg
HF*	Air	1.05E+04	µg	9.26E+03	µg
Hg	Water	2.01E+03	ng	2.01E+03	ng
Hg	Air	6.33E+04	ng	5.97E+04	ng
K*	Air	5.26E+04	mg	5.26E+04	mg
kerosene*	Air	7.08E+02	µg	5.92E+02	µg
limestone*	Raw	7.84E+03	g	7.84E+03	g
metallic ions*	Water	3.21E+04	µg	3.20E+04	µg
metals	Air	2.59E+03	µg	2.55E+03	µg
methane	Air	7.19E+04	mg	7.13E+04	mg
methanol	Air	2.35E+04	mg	2.29E+04	mg
methyl bromide	Air	2.74E+03	mg	2.79E+03	mg
methyl ethyl ketone	Air	6.83E+03	mg	7.03E+03	mg
methyl i-butyl ketone	Air	4.58E+03	mg	5.02E+03	mg
Mn*	Water	3.34E+04	µg	2.93E+04	µg
Mn*	Air	6.07E+02	mg	6.07E+02	mg
n-nitrodimethylamine*	Air	3.23E+03	ng	2.84E+03	ng
N2O	Air	8.75E+03	µg	7.74E+03	µg
Na*	Air	1.21E+03	mg	1.21E+03	mg
Na*	Water	1.12E+03	µg	9.36E+02	µg
naphthalene*	Air	1.61E+05	µg	1.61E+05	µg
natural gas	Raw	1.08E+04	g	1.08E+04	g
NH3*	Water	1.39E+04	µg	1.37E+04	µg
Ni	Air	3.88E+04	µg	3.88E+04	µg
nitrate*	Water	2.66E+05	ng	2.22E+05	ng
non methane VOC	Air	1.06E+05	mg	1.06E+05	mg
NOx	Air	2.36E+05	mg	2.35E+05	mg
o-xylene	Air	1.36E+03	mg	1.42E+03	mg
oil*	Water	9.92E+03	mg	9.92E+03	mg
organic substances*	Air	1.14E+04	mg	1.14E+04	mg
other organics*	Water	1.61E+03	mg	1.61E+03	mg
particulates*	Air	7.49E+01	g	2.08E+01	g
Pb	Water	2.67E+03	ng	2.67E+03	ng
Pb	Air	1.04E+05	µg	1.04E+05	µg
phenol*	Water	1.04E+05	ng	1.04E+05	ng
phenol*	Air	6.68E+03	mg	4.92E+03	mg
phosphate*	Water	5.97E+03	µg	5.41E+03	µg
radioactive substance to air*	Non mat.	1.84E+04	Bq	1.60E+04	Bq
Sb*	Air	2.70E+04	ng	2.62E+04	ng
Se*	Air	1.29E+05	ng	1.16E+05	ng

*Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	WESP Emissions / MSF:	Unit:	No WESP Emission / MSF:	Unit:
solid waste*	Solid	7.49E+03	g	7.44E+03	g
SOx	Air	3.90E+02	g	3.88E+02	g
styrene	Air	3.01E+03	mg	3.07E+03	mg
sulphate*	Water	2.04E+04	mg	2.03E+04	mg
suspended solids*	Water	1.06E+04	mg	1.06E+04	mg
tetrachloroethene	Air	1.48E+04	ng	1.31E+04	ng
tetrachloromethane	Air	3.49E+04	ng	3.29E+04	ng
toluene	Air	2.66E+03	mg	3.10E+03	mg
trichloroethene	Air	1.44E+04	ng	1.27E+04	ng
uranium*	Raw	6.48E+03	µg	5.92E+03	µg
vinyl chloride	Air	3.09E+03	mg	1.84E+03	mg
wood and wood wastes*	Raw	2.69E+04	mg	2.69E+04	mg
xylene	Air	1.53E+03	mg	2.46E+03	mg
Zn	Water	8.80E+03	µg	8.80E+03	µg
Zn	Air	2.96E+05	µg	2.96E+05	µg

*Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Drying machine center emissions comparison for manufacturing MCF of LVL in the PNW: WESP versus no WESP.

Substance:	Category:	WESP Emission / MCF:	Unit:	No WESP Emission / MCF:	Unit:
1,2,4-trichlorobenzene	Air	1.69E+05	mg	1.72E+05	mg
1,2-dichloroethane	Air	9.22E+04	mg	9.39E+04	mg
acetaldehyde	Air	4.10E+05	mg	4.10E+05	mg
acetone	Air	2.78E+05	mg	4.05E+05	mg
Acid as H+*	Water	4.79E+04	ng	4.79E+04	ng
acrolein	Air	1.71E+05	mg	1.27E+05	mg
aldehydes	Air	1.94E+05	mg	1.98E+05	mg
alkenes	Air	1.66E+07	mg	1.58E+07	mg
ammonia	Air	3.35E+05	µg	3.23E+05	µg
As	Air	1.92E+05	µg	1.92E+05	µg
B*	Water	1.56E+06	µg	1.44E+06	µg
Ba*	Air	9.47E+06	µg	9.47E+06	µg
Be*	Air	8.64E+05	ng	8.52E+05	ng
benzene	Air	8.00E+04	mg	7.01E+04	mg
BOD*	Water	1.79E+04	mg	1.79E+04	mg
Ca*	Water	1.99E+04	µg	1.72E+04	µg
Cd	Water	8.20E+05	µg	8.19E+05	µg
Cd	Air	5.21E+06	ng	5.21E+06	ng
chromate*	Water	1.82E+06	ng	1.82E+06	ng
Cl-*	Water	8.20E+05	mg	8.20E+05	mg
Cl2*	Air	1.67E+04	mg	1.67E+04	mg
CO*	Air	3.15E+04	g	3.15E+04	g
CO2	Air	4.52E+06	g	4.52E+06	g
CO2 (fossil)	Air	9.29E+05	g	9.26E+05	g
CO2 (non-fossil)	Air	2.09E+05	mg	2.08E+05	mg
coal	Raw	4.35E+06	g	4.35E+06	g
cobalt*	Air	2.34E+06	ng	2.31E+06	ng
COD*	Water	2.54E+05	mg	2.54E+05	mg
Cr	Water	8.20E+05	µg	8.19E+05	µg
Cr	Air	1.17E+05	µg	1.17E+05	µg
crude oil	Raw	7.52E+04	g	7.50E+04	g
CxHy aromatic	Air	4.70E+06	mg	4.80E+06	mg
CxHy chloro	Air	1.91E+05	mg	1.35E+05	mg
cyanide*	Water	1.23E+06	ng	1.23E+06	ng
dichloromethane	Air	7.85E+04	mg	8.03E+04	mg
dioxin (TEQ)	Air	2.76E+03	pg	2.51E+03	pg
dissolved solids*	Water	1.81E+04	g	1.81E+04	g
energy from hydro power*	Raw	4.64E+06	kJ	3.87E+06	kJ

*Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	WESP Emission / MCF:	Unit:	No WESP Emission / MCF:	Unit:

Fe*	Air	9.47E+06	µg	9.47E+06	µg
Fe*	Water	2.14E+06	µg	1.92E+06	µg
fluoride ions*	Water	9.21E+04	µg	8.00E+04	µg
formaldehyde	Air	2.13E+05	mg	4.03E+05	mg
H2SO4*	Water	3.90E+05	µg	3.60E+05	µg
HCl*	Air	2.58E+06	µg	2.34E+06	µg
HF*	Air	3.53E+05	µg	3.21E+05	µg
Hg	Water	6.44E+04	ng	6.43E+04	ng
Hg	Air	2.08E+06	ng	1.98E+06	ng
K*	Air	1.67E+06	mg	1.67E+06	mg
kerosene*	Air	2.31E+04	µg	2.01E+04	µg
limestone*	Raw	2.51E+05	g	2.51E+05	g
metallic ions*	Water	1.02E+06	µg	1.02E+06	µg
metals	Air	8.30E+04	µg	8.22E+04	µg
methane	Air	2.29E+06	mg	2.29E+06	mg
methanol	Air	7.52E+05	mg	7.33E+05	mg
methyl bromide	Air	8.77E+04	mg	8.94E+04	mg
methyl ethyl ketone	Air	2.19E+05	mg	2.26E+05	mg
methyl i-butyl ketone	Air	1.47E+05	mg	1.61E+05	mg
Mn*	Water	1.12E+06	µg	1.01E+06	µg
Mn*	Air	1.94E+04	mg	1.94E+04	mg
n-nitrodimethylamine*	Air	1.08E+05	ng	9.83E+04	ng
N2O	Air	2.95E+05	µg	2.68E+05	µg
Na*	Air	3.88E+04	mg	3.88E+04	mg
Na*	Water	3.67E+04	µg	3.18E+04	µg
naphthalene*	Air	5.17E+06	µg	5.17E+06	µg
natural gas	Raw	3.46E+05	g	3.46E+05	g
NH3*	Water	4.45E+05	µg	4.40E+05	µg
Ni	Air	1.24E+06	µg	1.24E+06	µg
nitrate*	Water	8.69E+06	ng	7.55E+06	ng
non methane VOC	Air	3.40E+06	mg	3.40E+06	mg
NOx	Air	7.55E+06	mg	7.53E+06	mg
o-xylene	Air	4.35E+04	mg	4.55E+04	mg
oil*	Water	3.18E+05	mg	3.18E+05	mg
organic substances*	Air	3.65E+05	mg	3.65E+05	mg
other organics*	Water	5.17E+04	mg	5.17E+04	mg
particulates*	Air	2.39E+03	g	6.70E+02	g
Pb	Water	8.52E+04	ng	8.52E+04	ng
Pb	Air	3.30E+06	µg	3.30E+06	µg
phenol*	Water	3.31E+06	ng	3.31E+06	ng
phenol*	Air	2.13E+05	mg	1.58E+05	mg
phosphate*	Water	1.98E+05	µg	1.82E+05	µg
radioactive substance to air*	Non mat.	6.21E+05	Bq	5.66E+05	Bq
Sb*	Air	8.74E+05	ng	8.54E+05	ng
Se*	Air	4.30E+06	ng	3.97E+06	ng

*Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	WESP Emission / MCF:	Unit:	No WESP Emission / MCF:	Unit:
solid waste*	Solid	2.39E+05	g	2.39E+05	g
SOx	Air	1.25E+04	g	1.25E+04	g
styrene	Air	9.62E+04	mg	9.83E+04	mg
sulphate*	Water	6.54E+05	mg	6.53E+05	mg
suspended solids*	Water	3.41E+05	mg	3.40E+05	mg
tetrachloroethene	Air	4.95E+05	ng	4.50E+05	ng
tetrachloromethane	Air	1.14E+06	ng	1.09E+06	ng
toluene	Air	8.50E+04	mg	9.93E+04	mg
trichloroethene	Air	4.82E+05	ng	4.39E+05	ng
uranium*	Raw	2.09E+05	μg	1.94E+05	μg
vinyl chloride	Air	9.89E+04	mg	5.89E+04	mg
wood and wood wastes*	Raw	8.62E+05	mg	8.60E+05	mg
xylene	Air	4.89E+04	mg	3.11E+04	mg
Zn	Water	2.83E+05	μg	2.81E+05	μg
Zn	Air	9.47E+06	μg	9.47E+06	μg

*Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Drying machine center emissions comparison for manufacturing MCF of LVL in the Southern region: RTO versus No RTO.

Substance:	Category:	No RTO Emission / MCF:	Unit:	RTO Emission / MCF:	Unit:
1,2,4-trichlorobenzene	Air	1.13E+05	mg	6.94E+04	mg
1,2-dichloroethane	Air	4.50E+04	mg	3.81E+04	mg
acetaldehyde	Air	9.56E+05	mg	6.52E+05	mg
acetone	Air	1.25E+06	mg	9.14E+05	mg
Acid as H+*	Water	4.01E+04	ng	4.24E+04	ng
acrolein	Air	2.51E+05	mg	2.32E+05	mg
aldehydes	Air	1.07E+05	mg	9.30E+04	mg
alkenes	Air	7.95E+07	mg	3.08E+07	mg
ammonia	Air	9.07E+05	µg	1.06E+06	µg
As	Air	1.55E+05	µg	1.63E+05	µg
B*	Water	7.59E+06	µg	8.93E+06	µg
Ba*	Air	7.34E+06	µg	7.67E+06	µg
Be*	Air	1.16E+06	ng	1.31E+06	ng
benzene	Air	1.49E+05	mg	1.36E+05	mg
BOD*	Water	4.29E+04	mg	4.50E+04	mg
Ca*	Water	7.49E+04	µg	8.87E+04	µg
Cd	Water	1.99E+06	µg	2.09E+06	µg
Cd	Air	6.17E+06	ng	6.55E+06	ng
chromate*	Water	4.31E+06	ng	4.70E+06	ng
Cl-*	Water	1.99E+06	mg	2.09E+06	mg
Cl2*	Air	1.30E+07	µg	1.36E+07	µg
CO*	Air	2.76E+04	g	2.93E+04	g
CO2	Air	3.51E+06	g	3.66E+06	g
CO2 (fossil)	Air	2.15E+06	g	2.28E+06	g
CO2 (non-fossil)	Air	4.89E+05	mg	5.21E+05	mg
coal	Raw	3.43E+06	g	3.60E+06	g
cobalt*	Air	6.50E+06	ng	7.21E+06	ng
COD*	Water	6.17E+05	mg	6.46E+05	mg
Cr	Water	1.99E+06	µg	2.09E+06	µg
Cr	Air	9.47E+04	µg	1.00E+05	µg
crude oil	Raw	6.23E+04	g	6.55E+04	g
CxHy aromatic	Air	2.32E+06	mg	1.94E+06	mg
CxHy chloro	Air	7.36E+04	mg	6.15E+04	mg
cyanide*	Water	3.01E+06	ng	3.14E+06	ng
dichloromethane	Air	3.87E+04	mg	3.26E+04	mg
dioxin (TEQ)	Air	1.52E+04	pg	1.80E+04	pg
dissolved solids*	Water	4.41E+04	g	4.62E+04	g
energy from hydro power*	Raw	1.51E+05	kJ	1.83E+05	kJ
ethane	Air	3.26E+04	mg		mg
Fe*	Air	7.34E+06	µg	7.67E+06	µg
Fe*	Water	1.09E+04	mg	1.30E+04	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RTO Emission / MCF:	Unit:	RTO Emission / MCF:	Unit:
fluoride ions*	Water	3.47E+05	µg	4.12E+05	µg
formaldehyde	Air	1.58E+06	mg	1.38E+06	mg
H2SO4*	Water	1.90E+06	µg	2.22E+06	µg
HCl*	Air	1.41E+04	mg	1.68E+04	mg
HF*	Air	1.95E+06	µg	2.32E+06	µg
Hg	Water	1.57E+05	ng	1.65E+05	ng
Hg	Air	6.21E+06	ng	7.21E+06	ng
K*	Air	1.30E+06	mg	1.36E+06	mg
kerosene*	Air	8.70E+04	µg	1.03E+05	µg
limestone*	Raw	1.97E+05	g	2.07E+05	g
metallic ions*	Water	8.59E+05	µg	9.07E+05	µg
metals	Air	1.94E+05	µg	2.07E+05	µg
methane	Air	5.94E+06	mg	6.61E+06	mg
methanol	Air	1.69E+06	mg	7.69E+05	mg
methyl bromide	Air	4.33E+04	mg	3.62E+04	mg
methyl ethyl ketone	Air	1.12E+05	mg	9.56E+04	mg
methyl i-butyl ketone	Air	1.23E+05	mg	1.07E+05	mg
Mn*	Water	6.13E+06	µg	7.26E+06	µg
Mn*	Air	1.50E+07	µg	1.57E+07	µg
n-nitrodimethylamine*	Air	5.94E+05	ng	7.03E+05	ng
N2O	Air	1.59E+06	µg	1.89E+06	µg
Na*	Air	3.01E+04	mg	3.14E+04	mg
Na*	Water	1.38E+05	µg	1.63E+05	µg
naphthalene*	Air	4.01E+06	µg	4.18E+06	µg
natural gas	Raw	8.34E+05	g	8.74E+05	g
NH3*	Water	1.01E+06	µg	1.08E+06	µg
Ni	Air	1.01E+06	µg	1.06E+06	µg
nitrate*	Water	3.28E+04	µg	3.87E+04	µg
non methane VOC	Air	7.88E+06	mg	8.26E+06	mg
NOx	Air	1.06E+07	mg	1.11E+07	mg
o-xylene	Air	4.85E+04	mg	4.02E+04	mg
oil*	Water	7.72E+05	mg	8.11E+05	mg
organic substances*	Air	2.91E+05	mg	3.05E+05	mg
other organics*	Water	1.27E+05	mg	1.33E+05	mg
particulates*	Air	1.80E+04	g	9.39E+02	g
Pb	Water	7.11E+04	ng	7.51E+04	ng
Pb	Air	2.82E+06	µg	2.95E+06	µg
phenol*	Water	2.76E+06	ng	2.93E+06	ng
phenol*	Air	2.07E+05	mg	2.13E+05	mg
phosphate*	Water	9.56E+05	µg	1.12E+06	µg
radioactive substance to air*	Non mat.	3.70E+06	Bq	4.41E+06	Bq
Sb*	Air	2.45E+06	ng	2.74E+06	ng
Se*	Air	2.11E+04	µg	2.49E+04	µg
solid waste*	Solid	2.70E+05	g	2.87E+05	g
SOx	Air	3.05E+04	g	3.20E+04	g

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RTO Emission / MCF:	Unit:	RTO Emission / MCF:	Unit:
styrene	Air	5.10E+04	mg	4.31E+04	mg
suspended solids*	Water	9.01E+05	mg	9.60E+05	mg
tetrachloroethene	Air	2.68E+06	ng	3.18E+06	ng
tetrachloromethane	Air	4.87E+06	ng	5.62E+06	ng
toluene	Air	1.69E+05	mg	1.62E+05	mg
trichloroethene	Air	2.64E+06	ng	3.14E+06	ng
uranium*	Raw	4.75E+05	µg	5.52E+05	µg
vinyl chloride	Air	2.84E+04	mg	2.38E+04	mg
wood and wood wastes*	Raw	9.30E+05	mg	9.79E+05	mg
xylene	Air	9.14E+04	mg	8.32E+04	mg
Zn	Water	6.86E+05	µg	7.19E+05	µg
Zn	Air	7.34E+06	µg	7.67E+06	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Drying machine center emissions comparison for the manufacturing MSF 3/8" basis in the Southern region: RTO versus no RTO.

		No RTO		RTO	
Substance:	Category:	Emission / MSF:	Unit:	Emission / MSF:	Unit:
1,2,4-trichlorobenzene	Air	2.59E+03	mg	2.17E+03	mg
1,2-dichloroethane	Air	1.41E+03	mg	1.19E+03	mg
acetaldehyde	Air	2.99E+04	mg	2.04E+04	mg
acetone	Air	3.91E+04	mg	2.85E+04	mg
Acid as H+*	Water	1.26E+03	ng	1.33E+03	ng
acrolein	Air	7.87E+03	mg	7.24E+03	mg
aldehydes	Air	3.35E+03	mg	2.91E+03	mg
alkenes	Air	2.49E+03	g	9.66E+02	g
ammonia	Air	2.83E+04	µg	3.31E+04	µg
As	Air	4.86E+03	µg	5.11E+03	µg
B*	Water	2.37E+02	mg	2.79E+02	mg
Ba*	Air	2.29E+05	µg	2.40E+05	µg
Be*	Air	3.61E+04	ng	4.09E+04	ng
benzene	Air	4.67E+03	mg	4.27E+03	mg
BOD*	Water	1.34E+03	mg	1.41E+03	mg
Ca*	Water	2.29E+03	µg	2.73E+03	µg
Cd	Water	6.25E+04	µg	6.54E+04	µg
Cd	Air	1.93E+05	ng	2.05E+05	ng
chromate*	Water	1.36E+05	ng	1.49E+05	ng
Cl-*	Water	6.25E+04	mg	6.54E+04	mg
Cl2*	Air	4.06E+05	mg	4.25E+05	mg
CO*	Air	8.63E+02	g	9.15E+02	g
CO2	Air	1.09E+05	g	1.15E+05	g
CO2 (fossil)	Air	6.72E+04	g	7.12E+04	g
CO2 (non-fossil)	Air	1.52E+04	mg	1.63E+04	mg
coal	Raw	1.07E+05	g	1.12E+05	g
cobalt*	Air	2.03E+02	µg	2.27E+02	µg
COD*	Water	1.92E+04	mg	2.01E+04	mg
Cr	Water	6.25E+04	µg	6.54E+04	µg
Cr	Air	2.95E+03	µg	3.13E+03	µg
crude oil	Raw	1.95E+03	g	2.06E+03	g
CxHy aromatic	Air	7.24E+04	mg	6.08E+04	mg
CxHy chloro	Air	2.30E+03	mg	1.92E+03	mg
cyanide*	Water	9.38E+04	ng	9.84E+04	ng
dichloromethane	Air	1.21E+03	mg	1.02E+03	mg
dioxin (TEQ)	Air	4.74E+02	pg	5.62E+02	pg
dissolved solids*	Water	1.38E+03	g	1.44E+03	g
energy from hydro power*	Raw	5.00E+03	kJ	6.02E+03	kJ
ethane	Air	1.02E+03	mg		mg
Fe*	Air	2.29E+05	µg	2.40E+05	µg
Fe*	Water	3.40E+02	mg	4.04E+02	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RTO Emission / MSF:	Unit:	RTO Emission / MSF:	Unit:
fluoride ions*	Water	1.06E+04	µg	1.26E+04	µg
formaldehyde	Air	4.92E+04	mg	4.31E+04	mg
H2SO4*	Water	5.91E+04	µg	6.95E+04	µg
HCl*	Air	4.42E+02	mg	5.23E+02	mg
HF*	Air	6.08E+01	mg	7.24E+01	mg
Hg	Water	4.91E+03	ng	5.14E+03	ng
Hg	Air	1.93E+02	µg	2.25E+02	µg
K*	Air	4.06E+04	mg	4.25E+04	mg
kerosene*	Air	2.66E+03	µg	3.17E+03	µg
limestone*	Raw	6.20E+03	g	6.48E+03	g
metallic ions*	Water	2.69E+04	µg	2.84E+04	µg
metals	Air	6.02E+03	µg	6.43E+03	µg
methane	Air	1.86E+05	mg	2.07E+05	mg
methanol	Air	5.29E+04	mg	2.40E+04	mg
methyl bromide	Air	1.35E+03	mg	1.13E+03	mg
methyl ethyl ketone	Air	3.51E+03	mg	2.99E+03	mg
methyl i-butyl ketone	Air	3.86E+03	mg	3.34E+03	mg
Mn*	Water	1.91E+02	mg	2.26E+02	mg
Mn*	Air	4.70E+05	mg	4.91E+05	mg
n-nitrodimethylamine*	Air	1.85E+04	ng	2.19E+04	ng
N2O	Air	4.98E+04	µg	5.91E+04	µg
Na*	Air	9.38E+02	mg	9.79E+02	mg
Na*	Water	4.21E+03	µg	5.01E+03	µg
naphthalene*	Air	1.25E+05	µg	1.31E+05	µg
natural gas	Raw	2.61E+04	g	2.73E+04	g
NH3*	Water	3.15E+04	µg	3.36E+04	µg
Ni	Air	3.16E+04	µg	3.32E+04	µg
nitrate*	Water	9.96E+02	µg	1.19E+03	µg
non methane VOC	Air	2.46E+05	mg	2.58E+05	mg
NOx	Air	3.29E+05	mg	3.48E+05	mg
o-xylene	Air	1.52E+03	mg	1.26E+03	mg
oil*	Water	2.41E+04	mg	2.53E+04	mg
organic substances*	Air	9.09E+03	mg	9.50E+03	mg
other organics*	Water	3.97E+03	mg	4.16E+03	mg
particulates*	Air	5.61E+02	g	2.93E+01	g
Pb	Water	2.22E+03	ng	2.35E+03	ng
Pb	Air	8.80E+04	µg	9.21E+04	µg
phenol*	Water	8.69E+04	ng	9.15E+04	ng
phenol*	Air	6.43E+03	mg	6.66E+03	mg
phosphate*	Water	2.99E+04	µg	3.51E+04	µg
radioactive substance to air*	Non mat.	1.16E+05	Bq	1.38E+05	Bq
Sb*	Air	7.64E+04	ng	8.51E+04	ng
Se*	Air	6.60E+02	µg	7.76E+02	µg
solid waste*	Solid	8.40E+03	g	8.97E+03	g
SOx	Air	9.50E+02	g	1.00E+03	g

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RTO Emission / MSF:	Unit:	RTO Emission / MSF:	Unit:
styrene	Air	1.60E+03	mg	1.35E+03	mg
sulphate*	Water	5.03E+04	mg	5.29E+04	mg
suspended solids*	Water	2.81E+04	mg	2.99E+04	mg
tetrachloroethene	Air	8.40E+01	µg	9.96E+01	µg
tetrachloromethane	Air	1.53E+02	µg	1.78E+02	µg
toluene	Air	5.28E+03	mg	5.07E+03	mg
trichloroethene	Air	8.28E+01	µg	9.79E+01	µg
uranium*	Raw	1.45E+04	µg	1.70E+04	µg
vinyl chloride	Air	8.86E+02	mg	7.47E+02	mg
wood and wood wastes*	Raw	2.90E+04	mg	3.06E+04	mg
xylene	Air	2.85E+03	mg	2.60E+03	mg
Zn	Water	2.14E+04	µg	2.25E+04	µg
Zn	Air	2.29E+05	µg	2.40E+05	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Drying machine center emissions comparison for manufacturing MCF of LVL in the Southern region: RCO versus no RCO with one direct-natural gas-fired dryer and one indirect steam heated dryer

Substance:	Category:	No RCO Emission / MCF:	Unit:	RCO Emission / MCF:	Unit:
1,2,4-trichlorobenzene	Air	9.31E+04	mg	8.39E+04	mg
1,2-dichloroethane	Air	4.25E+04	mg	4.48E+04	mg
acetaldehyde	Air	1.08E+06	mg	1.52E+06	mg
acetone	Air	1.51E+06	mg	1.59E+06	mg
Acid as H+*	Water	3.99E+04	ng	4.08E+04	ng
acrolein	Air	3.20E+05	mg	2.45E+05	mg
aldehydes	Air	1.01E+05	mg	1.08E+05	mg
alkenes	Air	6.46E+04	g	3.20E+04	g
ammonia	Air	9.03E+05	µg	1.02E+06	µg
As	Air	1.55E+05	µg	1.58E+05	µg
B*	Water	7.55E+06	µg	8.62E+06	µg
Ba*	Air	7.34E+06	µg	7.44E+06	µg
Be*	Air	1.15E+06	ng	1.26E+06	ng
benzene	Air	2.01E+05	mg	1.50E+05	mg
BOD*	Water	4.14E+04	mg	4.37E+04	mg
Ca*	Water	7.47E+04	µg	8.57E+04	µg
Cd	Water	1.94E+06	µg	2.03E+06	µg
Cd	Air	6.04E+06	ng	6.34E+06	ng
chromate*	Water	4.22E+06	ng	4.52E+06	ng
Cl-*	Water	1.94E+06	mg	2.03E+06	mg
Cl2*	Air	1.30E+07	µg	1.32E+07	µg
CO*	Air	3.12E+04	g	2.78E+04	g
CO2	Air	3.51E+06	g	3.55E+06	g
CO2 (fossil)	Air	2.09E+06	g	2.20E+06	g
CO2 (non-fossil)	Air	4.73E+05	mg	5.06E+05	mg
coal FAL	Raw	3.43E+06	g	3.49E+06	g
cobalt*	Air	6.36E+06	ng	6.98E+06	ng
COD*	Water	5.94E+05	mg	6.27E+05	mg
Cr	Water	1.94E+06	µg	2.03E+06	µg
Cr	Air	9.45E+04	µg	9.70E+04	µg
crude oil	Raw	6.19E+04	g	6.34E+04	g
CxHy aromatic	Air	2.18E+06	mg	2.34E+06	mg
CxHy chloro	Air	6.94E+04	mg	7.38E+04	mg
cyanide*	Water	2.89E+06	ng	3.05E+06	ng
dichloromethane	Air	3.64E+04	mg	3.97E+04	mg
dioxin (TEQ)	Air	1.51E+04	pg	1.73E+04	pg
dissolved solids*	Water	4.25E+04	g	4.48E+04	g
energy from hydro power*	Raw	1.51E+05	kJ	1.77E+05	kJ
ethane	Air	4.91E+04	mg	1.31E+05	mg
Fe*	Air	7.34E+06	µg	7.44E+06	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RCO Emission / MCF:	Unit:	RCO Emission / MCF:	Unit:
Fe*	Water	1.09E+04	mg	1.25E+04	mg
fluoride ions*	Water	3.45E+05	µg	3.97E+05	µg
formaldehyde	Air	2.13E+06	mg	1.90E+06	mg
H2SO4*	Water	1.89E+06	µg	2.15E+06	µg
HCl*	Air	1.41E+04	mg	1.62E+04	mg
HF*	Air	1.94E+06	µg	2.22E+06	µg
Hg	Water	1.52E+05	ng	1.60E+05	ng
Hg	Air	6.17E+06	ng	6.96E+06	ng
K*	Air	1.30E+06	mg	1.32E+06	mg
kerosene*	Air	8.68E+04	µg	9.97E+04	µg
limestone*	Raw	1.97E+05	g	2.01E+05	g
metallic ions*	Water	8.51E+05	µg	8.76E+05	µg
metals	Air	1.88E+05	µg	1.99E+05	µg
methane	Air	6.55E+06	mg	7.36E+06	mg
methanol	Air	1.49E+06	mg	8.13E+05	mg
methyl bromide	Air	4.06E+04	mg	4.37E+04	mg
methyl ethyl ketone	Air	1.05E+05	mg	1.12E+05	mg
methyl i-butyl ketone	Air	1.23E+05	mg	1.23E+05	mg
Mn*	Water	6.11E+06	µg	7.01E+06	µg
Mn*	Air	1.50E+07	µg	1.52E+07	µg
n-nitrodimethylamine*	Air	5.92E+05	ng	6.78E+05	ng
N2O	Air	1.59E+06	µg	1.82E+06	µg
Na*	Air	3.01E+04	mg	3.05E+04	mg
Na*	Water	1.37E+05	µg	1.58E+05	µg
naphthalene*	Air	4.01E+06	µg	4.06E+06	µg
natural gas	Raw	8.05E+05	g	8.47E+05	g
NH3*	Water	9.81E+05	µg	1.04E+06	µg
Ni	Air	1.01E+06	µg	1.03E+06	µg
nitrate*	Water	3.26E+04	µg	3.74E+04	µg
non methane VOC	Air	7.61E+06	mg	8.01E+06	mg
NOx	Air	1.04E+07	mg	1.08E+07	mg
o-xylene	Air	4.58E+04	mg	4.81E+04	mg
oil*	Water	7.46E+05	mg	7.86E+05	mg
organic substances*	Air	2.89E+05	mg	2.95E+05	mg
other organics*	Water	1.23E+05	mg	1.29E+05	mg
particulates*	Air	1.30E+04	g	9.14E+02	g
Pb	Water	7.05E+04	ng	7.24E+04	ng
Pb	Air	2.82E+06	µg	2.86E+06	µg
phenol*	Water	2.74E+06	ng	2.82E+06	ng
phenol*	Air	2.01E+05	mg	2.34E+05	mg
phosphate*	Water	9.51E+05	µg	1.08E+06	µg
radioactive substance to air*	Non mat.	3.70E+06	Bq	4.25E+06	Bq
Sb*	Air	2.41E+06	ng	2.64E+06	ng
Se*	Air	2.11E+04	µg	2.40E+04	µg
solid waste*	Solid	2.66E+05	g	2.78E+05	g

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RCO Emission / MCF:	Unit:	RCO Emission / MCF:	Unit:
SOx	Air	2.95E+04	g	3.10E+04	g
styrene	Air	5.00E+04	mg	5.12E+04	mg
sulphate*	Water	1.56E+06	mg	1.64E+06	mg
suspended solids*	Water	8.72E+05	mg	9.30E+05	mg
tetrachloroethene	Air	2.68E+06	ng	3.07E+06	ng
tetrachloromethane	Air	4.81E+06	ng	5.42E+06	ng
toluene	Air	2.30E+05	mg	1.70E+05	mg
trichloroethene	Air	2.64E+06	ng	3.03E+06	ng
uranium*	Raw	4.73E+05	µg	5.33E+05	µg
vinyl chloride	Air	2.68E+04	mg	2.86E+04	mg
wood and wood wastes*	Raw	9.18E+05	mg	9.49E+05	mg
xylene	Air	1.10E+05	mg	9.10E+04	mg
Zn	Water	6.63E+05	µg	6.98E+05	µg
Zn	Air	7.34E+06	µg	7.44E+06	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Drying machine center emissions comparison for the manufacturing MSF 3/8" basis in the Southern region: RCO versus No RCO with one direct-natural gas-fired dryer and one indirect steam heated dryer

		No RCO		RCO	
Substance:	Category:	Emission / MSF:	Unit:	Emission / MSF:	Unit:
1,2,4-trichlorobenzene	Air	2.44E+03	mg	2.62E+03	mg
1,2-dichloroethane	Air	1.33E+03	mg	1.40E+03	mg
acetaldehyde	Air	3.39E+04	mg	4.74E+04	mg
acetone	Air	4.72E+04	mg	4.98E+04	mg
Acid as H+*	Water	1.24E+03	ng	1.28E+03	ng
acrolein	Air	1.00E+04	mg	7.64E+03	mg
aldehydes	Air	3.15E+03	mg	3.38E+03	mg
alkenes	Air	2.01E+03	g	1.00E+03	g
ammonia	Air	2.81E+04	µg	3.18E+04	µg
As	Air	4.85E+03	µg	4.94E+03	µg
B*	Water	2.36E+02	mg	2.69E+02	mg
Ba*	Air	2.29E+05	µg	2.32E+05	µg
Be*	Air	3.59E+04	ng	3.95E+04	ng
benzene	Air	6.31E+03	mg	4.70E+03	mg
BOD*	Water	1.30E+03	mg	1.36E+03	mg
Ca*	Water	2.28E+03	µg	2.63E+03	µg
Cd	Water	6.02E+04	µg	6.37E+04	µg
Cd	Air	1.89E+05	ng	1.98E+05	ng
chromate*	Water	1.33E+05	ng	1.43E+05	ng
Cl-*	Water	6.02E+04	mg	6.37E+04	mg
Cl2*	Air	4.06E+05	µg	4.12E+05	µg
CO*	Air	9.73E+02	g	8.69E+02	g
CO2	Air	1.09E+05	g	1.11E+05	g
CO2 (fossil)	Air	6.48E+04	g	6.89E+04	g
CO2 (non-fossil)	Air	1.48E+04	mg	1.57E+04	mg
coal FAL	Raw	1.07E+05	g	1.09E+05	g
cobalt*	Air	2.00E+02	µg	2.19E+02	µg
COD*	Water	1.86E+04	mg	1.95E+04	mg
Cr	Water	6.02E+04	µg	6.37E+04	µg
Cr	Air	2.95E+03	µg	3.03E+03	µg
crude oil	Raw	1.94E+03	g	1.99E+03	g
CxHy aromatic	Air	6.83E+04	mg	7.30E+04	mg
CxHy chloro	Air	2.17E+03	mg	2.31E+03	mg
cyanide*	Water	9.03E+04	ng	9.50E+04	ng
dichloromethane	Air	1.14E+03	mg	1.24E+03	mg
dioxin (TEQ)	Air	4.72E+02	pg	5.42E+02	pg
dissolved solids*	Water	1.33E+03	g	1.40E+03	g
energy from hydro power*	Raw	5.00E+03	kJ	5.79E+03	kJ
ethane	Air	1.53E+03	mg	4.08E+03	mg
Fe*	Air	2.29E+05	µg	2.32E+05	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RCO Emission / MSF:	Unit:	RCO Emission / MSF:	Unit:
Fe*	Water	3.39E+02	mg	3.89E+02	mg
fluoride ions*	Water	1.05E+04	µg	1.22E+04	µg
formaldehyde	Air	6.66E+04	mg	5.96E+04	mg
H2SO4*	Water	5.91E+04	µg	6.72E+04	µg
HCl*	Air	4.40E+02	mg	5.05E+02	mg
HF*	Air	6.08E+01	mg	6.95E+01	mg
Hg	Water	4.74E+03	ng	4.99E+03	ng
Hg	Air	1.92E+02	µg	2.17E+02	µg
K*	Air	4.06E+04	mg	4.12E+04	mg
kerosene*	Air	2.65E+03	µg	3.05E+03	µg
limestone*	Raw	6.20E+03	g	6.31E+03	g
metallic ions*	Water	2.66E+04	µg	2.74E+04	µg
metals	Air	5.85E+03	µg	6.25E+03	µg
methane	Air	2.05E+05	mg	2.30E+05	mg
methanol	Air	4.66E+04	mg	2.54E+04	mg
methyl bromide	Air	1.27E+03	mg	1.36E+03	mg
methyl ethyl ketone	Air	3.29E+03	mg	3.51E+03	mg
methyl i-butyl ketone	Air	3.86E+03	mg	3.83E+03	mg
Mn*	Water	1.90E+02	mg	2.19E+02	mg
Mn*	Air	4.70E+05	µg	4.76E+05	µg
n-nitrodimethylamine*	Air	1.85E+04	ng	2.12E+04	ng
N2O	Air	4.96E+04	µg	5.69E+04	µg
Na*	Air	9.38E+02	mg	9.50E+02	mg
Na*	Water	4.19E+03	µg	4.83E+03	µg
naphthalene*	Air	1.25E+05	µg	1.27E+05	µg
natural gas	Raw	2.51E+04	g	2.65E+04	g
NH3*	Water	3.06E+04	µg	3.25E+04	µg
Ni	Air	3.16E+04	µg	3.22E+04	µg
nitrate*	Water	9.96E+02	µg	1.15E+03	µg
non methane VOC	Air	2.38E+05	mg	2.50E+05	mg
NOx	Air	3.26E+05	mg	3.37E+05	mg
o-xylene	Air	1.43E+03	mg	1.51E+03	mg
oil*	Water	2.33E+04	mg	2.45E+04	mg
organic substances*	Air	9.09E+03	mg	9.21E+03	mg
other organics*	Water	3.83E+03	mg	4.03E+03	mg
particulates*	Air	4.06E+02	g	2.85E+01	g
Pb	Water	2.21E+03	ng	2.26E+03	ng
Pb	Air	8.80E+04	µg	8.92E+04	µg
phenol*	Water	8.57E+04	ng	8.86E+04	ng
phenol*	Air	6.31E+03	mg	7.30E+03	mg
phosphate*	Water	2.97E+04	µg	3.39E+04	µg
radioactive substance to air*	Non mat.	1.15E+05	Bq	1.33E+05	Bq
Sb*	Air	7.53E+04	ng	8.28E+04	ng
Se*	Air	6.54E+02	µg	7.47E+02	µg
solid waste*	Solid	8.34E+03	g	8.69E+03	g

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	No RCO Emission / MSF:	Unit:	RCO Emission / MSF:	Unit:
SOx	Air	9.21E+02	g	9.73E+02	g
styrene	Air	1.56E+03	mg	1.60E+03	mg
sulphate*	Water	4.86E+04	mg	5.12E+04	mg
suspended solids*	Water	2.72E+04	mg	2.90E+04	mg
tetrachloroethene	Air	8.40E+01	µg	9.61E+01	µg
tetrachloromethane	Air	1.51E+02	µg	1.71E+02	µg
toluene	Air	7.18E+03	mg	5.31E+03	mg
trichloroethene	Air	8.22E+01	µg	9.44E+01	µg
uranium*	Raw	1.45E+04	µg	1.64E+04	µg
vinyl chloride	Air	8.34E+02	mg	8.97E+02	mg
wood and wood wastes*	Raw	2.87E+04	mg	2.96E+04	mg
xylene	Air	3.43E+03	mg	2.84E+03	mg
Zn	Water	2.07E+04	µg	2.18E+04	µg
Zn	Air	2.29E+05	µg	2.32E+05	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood 3/8" Basis in the PNW for the base case.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
1,2,4-trichlorobenzene	Air	15.40	mg	7.79	g
1,2-dichloroethane	Air	8.42	mg	4.26	g
acetaldehyde	Air	31.80	mg	16.09	g
acetone	Air	27.20	mg	13.76	g
Acid as H+*	Water	9.55	ng	4.83	µµg
acrolein	Air	16.10	mg	8.15	g
aldehydes	Air	20.50	mg	10.37	g
alkenes	Air	1,528.54	mg	773.44	g
ammonia	Air	70.80	µµg	35.82	mg
As	Air	18.50	µµg	9.36	mg
B*	Water	350.00	µµg	177.10	mg
Ba*	Air	895.00	µµg	452.87	mg
Be*	Air	117.00	ng	59.20	µµg
benzene	Air	7.18	mg	3.63	g
BOD*	Water	3.21	mg	1.62	g
Ca*	Water	4.90	µµg	2.48	mg
Cd	Water	151.00	µµg	76.41	mg
Cd	Air	759.00	ng	384.05	µµg
chromate*	Water	348.00	ng	176.09	µµg
Cl-*	Water	151.00	mg	76.41	g
Cl2*	Air	1.59	mg	0.80	g
CO*	Air	3.22	g	1.63	kg
CO2	Air	484.00	g	244.90	kg
CO2 (fossil)	Air	122.00	g	61.73	kg
CO2 (non-fossil)	Air	40.10	mg	20.29	g
coal	Raw	413.00	g	208.98	kg
cobalt*	Air	463.00	ng	234.28	µµg
COD*	Water	37.00	mg	18.72	g
Cr	Water	151.00	µµg	76.41	mg
Cr	Air	11.70	µµg	5.92	mg
crude oil	Raw	11.70	g	5.92	kg
CxHy aromatic	Air	432.00	mg	218.59	g
CxHy chloro	Air	21.50	mg	10.88	g
cyanide*	Water	227.00	ng	114.86	µµg
dichloromethane	Air	14.10	mg	7.13	g
dioxin (TEQ)	Air	0.64	pg	0.32	ng
dissolved solids*	Water	3.32	g	1.68	kg
Douglas-fir logs*	Raw	1.70	Kg	861	kg
energy from hydro power*	Raw	1,150.00	kJ	581.90	MJ
energy from oil	Raw	1.15	MJ	0.58	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
Fe*	Air	895.00	µg	452.87	mg
Fe*	Water	503.00	µg	254.52	mg
fluoride ions*	Water	22.70	µg	11.49	mg
formaldehyde	Air	63.80	mg	32.28	g
H2SO4*	Water	87.50	µg	44.28	mg
HCl*	Air	601.00	µg	304.11	mg
HF*	Air	82.60	µg	41.80	mg
Hg	Water	11.90	ng	6.02	µg
Hg	Air	370.00	ng	187.22	µg
K*	Air	159.00	mg	80.45	g
kerosene*	Air	5.69	µg	2.88	mg
limestone*	Raw	23.80	g	12.04	kg
metallic ions*	Water	204.00	µg	103.22	mg
metals	Air	15.90	µg	8.05	mg
methane	Air	429.00	mg	217.07	g
methanol	Air	108.00	mg	54.65	g
methyl bromide	Air	7.97	mg	4.03	g
methyl ethyl ketone	Air	17.60	mg	8.91	g
methyl i-butyl ketone	Air	36.90	mg	18.67	g
Mn*	Water	261.00	µg	132.07	mg
Mn*	Air	1.83	mg	0.93	g
n-nitrodimethylamine*	Air	25.30	ng	12.80	µg
N2O	Air	68.10	µg	34.46	mg
Na*	Air	3.66	mg	1.85	g
Na*	Water	9.02	µg	4.56	mg
naphthalene*	Air	488.00	µg	246.93	mg
natural gas (feedstock)	Raw	19.80	dm3	10,018.80	dm3
natural gas	Raw	63.30	g	32.03	kg
NH3*	Water	63.00	µg	31.88	mg
Ni	Air	121.00	µg	61.23	mg
nitrate*	Water	2,140.00	ng	1,082.84	µg
non methane VOC	Air	642.00	mg	324.85	g
NOx	Air	1,030.00	mg	521.18	g
o-xylene	Air	5.63	mg	2.85	g
oil*	Water	58.70	mg	29.70	g
organic substances*	Air	79.70	mg	40.33	g
other organics*	Water	9.56	mg	4.84	g
particulates*	Air	2.14	g	1.08	kg
Pb	Water	17.00	ng	8.60	µg
Pb	Air	327.00	µg	165.46	mg
phenol*	Water	660.00	ng	333.96	µg
phenol*	Air	91.40	mg	46.25	g
phosphate*	Water	44.30	µg	22.42	mg
radioactive substance to air*	Non mat.	144.00	Bq	72,864.00	Bq
Sb*	Air	175.00	ng	88.55	µg
Se*	Air	972.00	ng	491.83	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
SO2	Air	46.30	mg	23.43	g
solid waste*	Solid	26.50	g	13.41	kg
SOx	Air	2.27	g	1.15	kg
styrene	Air	8.80	mg	4.45	g
sulphate*	Water	121.00	mg	61.23	g
suspended solids*	Water	43.40	mg	21.96	g
tetrachloroethene	Air	115.00	ng	58.19	μg
tetrachloromethane	Air	239.00	ng	120.93	μg
toluene	Air	7.79	mg	3.94	g
trichloroethene	Air	113.00	ng	57.18	μg
uranium*	Raw	35.70	μg	18.06	mg
vinyl chloride	Air	7.82	mg	3.96	g
VOC	Air	54.60	mg	27.63	g
wood and wood wastes*	Raw	98.30	mg	49.74	g
xylene	Air	5.95	mg	3.01	g
Zn	Water	52.10	μg	26.36	mg
Zn	Air	895.00	μg	452.87	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood 3/8" basis in the PNW for the base case without a WESP.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
1,2,4-trichlorobenzene	Air	15.60	mg	7.89	g
1,2-dichloroethane	Air	8.52	mg	4.31	g
acetaldehyde	Air	31.80	mg	16.09	g
acetone	Air	35.10	mg	17.76	g
Acid as H+*	Water	9.55	ng	4.83	µg
acrolein	Air	13.40	mg	6.78	g
aldehydes	Air	20.60	mg	10.42	g
alkenes	Air	1,478.54	mg	748.14	g
ammonia	Air	69.80	µg	35.32	mg
As	Air	18.50	µg	9.36	mg
B*	Water	341.00	µg	172.55	mg
Ba*	Air	895.00	µg	452.87	mg
Be*	Air	116.00	ng	58.70	µg
benzene	Air	6.58	mg	3.33	g
BOD*	Water	3.21	mg	1.62	g
Ca*	Water	4.70	µg	2.38	mg
Cd	Water	151.00	µg	76.41	mg
Cd	Air	758.00	ng	383.55	µg
chromate*	Water	348.00	ng	176.09	µg
Cl-*	Water	151.00	mg	76.41	g
Cl2*	Air	1.59	mg	0.80	g
CO*	Air	3.22	g	1.63	kg
CO2	Air	484.00	g	244.90	kg
CO2 (fossil)	Air	121.00	g	61.23	kg
CO2 (non-fossil)	Air	39.90	mg	20.19	g
coal	Raw	413.00	g	208.98	kg
cobalt*	Air	460.00	ng	232.76	µg
COD*	Water	37.00	mg	18.72	g
Cr	Water	151.00	µg	76.41	mg
Cr	Air	11.70	µg	5.92	mg
crude oil	Raw	11.70	g	5.92	kg
CxHy aromatic	Air	438.00	mg	221.63	g
CxHy chloro	Air	18.10	mg	9.16	g
cyanide*	Water	227.00	ng	114.86	µg
dichloromethane	Air	14.20	mg	7.19	g
dioxin (TEQ)	Air	0.62	pg	0.31	ng
dissolved solids*	Water	3.32	g	1.68	kg
Douglas-fir*	Raw	1.70	kg	861.00	kg
energy from hydro power*	Raw	1,100.00	kJ	556.60	MJ
energy from oil	Raw	1.15	MJ	0.58	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
Fe*	Air	895.00	µg	452.87	mg
Fe*	Water	487.00	µg	246.42	mg
fluoride ions*	Water	21.80	µg	11.03	mg
formaldehyde	Air	75.60	mg	38.25	g
H2SO4*	Water	85.30	µg	43.16	mg
HCl*	Air	582.00	µg	294.49	mg
HF*	Air	80.00	µg	40.48	mg
Hg	Water	11.90	ng	6.02	µg
Hg	Air	363.00	ng	183.68	µg
K*	Air	159.00	mg	80.45	g
kerosene*	Air	5.46	µg	2.76	mg
limestone*	Raw	23.80	g	12.04	kg
metallic ions*	Water	204.00	µg	103.22	mg
metals	Air	15.90	µg	8.05	mg
methane	Air	428.00	mg	216.57	g
methanol	Air	107.00	mg	54.14	g
methyl bromide	Air	8.08	mg	4.09	g
methyl ethyl ketone	Air	18.00	mg	9.11	g
methyl i-butyl ketone	Air	37.70	mg	19.08	g
Mn*	Water	253.00	µg	128.02	mg
Mn*	Air	1.83	mg	0.93	g
n-nitrodimethylamine*	Air	24.50	ng	12.40	µg
N2O	Air	66.10	µg	33.45	mg
Na*	Air	3.66	mg	1.85	g
Na*	Water	8.65	µg	4.38	mg
naphthalene*	Air	488.00	µg	246.93	mg
natural gas (feedstock)	Raw	19.80	dm3	10,018.80	dm3
natural gas	Raw	63.30	g	32.03	kg
NH3*	Water	62.60	µg	31.68	mg
Ni	Air	121.00	µg	61.23	mg
nitrate*	Water	2,050.00	ng	1,037.30	µg
non methane VOC	Air	642.00	mg	324.85	g
NOx	Air	1,030.00	mg	521.18	g
o-xylene	Air	5.75	mg	2.91	g
oil*	Water	58.70	mg	29.70	g
organic substances*	Air	79.70	mg	40.33	g
other organics*	Water	9.56	mg	4.84	g
particulates*	Air	2.03	g	1.03	kg
Pb	Water	17.00	ng	8.60	µg
Pb	Air	327.00	µg	165.46	mg
phenol*	Water	660.00	ng	333.96	µg
phenol*	Air	87.90	mg	44.48	g
phosphate*	Water	43.20	µg	21.86	mg
radioactive substance to air*	Non mat.	140.00	Bq	70,840.00	Bq
Sb*	Air	173.00	ng	87.54	µg
Se*	Air	946.00	ng	478.68	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
SO2	Air	46.30	mg	23.43	g
solid waste*	Solid	26.50	g	13.41	kg
SOx	Air	2.26	g	1.14	kg
styrene	Air	8.93	mg	4.52	g
sulphate*	Water	121.00	mg	61.23	g
suspended solids*	Water	43.20	mg	21.86	g
tetrachloroethene	Air	112.00	ng	56.67	µg
tetrachloromethane	Air	235.00	ng	118.91	µg
toluene	Air	8.67	mg	4.39	g
trichloroethene	Air	109.00	ng	55.15	µg
uranium*	Raw	34.60	µg	17.51	mg
vinyl chloride	Air	5.35	mg	2.71	g
VOC	Air	54.60	mg	27.63	g
wood and wood wastes*	Raw	98.10	mg	49.64	g
xylene	Air	4.86	mg	2.46	g
Zn	Water	52.10	µg	26.36	mg
Zn	Air	895.00	µg	452.87	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood 3/8" Basis in the Pacific Northwest for the base case with 100% hog fuel for heating.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
1,2,4-trichlorobenzene	Air	15.40	mg	7.79	g
1,2-dichloroethane	Air	8.42	mg	4.26	g
acetaldehyde	Air	32.00	mg	16.19	g
acetone	Air	27.20	mg	13.76	g
Acid as H+*	Water	4.17	ng	2.11	μg
acrolein	Air	16.10	mg	8.15	g
aldehydes	Air	20.00	mg	10.12	g
alkenes	Air	1,528.54	mg	773.44	g
ammonia	Air	40.90	μg	20.70	mg
As	Air	25.60	μg	12.95	mg
B*	Water	279.00	μg	141.17	mg
Ba*	Air	1,270.00	μg	642.62	mg
Be*	Air	31.10	ng	15.74	μg
benzene	Air	7.49	mg	3.79	g
BOD*	Water	1.20	mg	0.61	g
Ca*	Water	4.58	μg	2.32	mg
Cd	Water	59.70	μg	30.21	mg
Cd	Air	186.00	ng	94.12	μg
chromate*	Water	147.00	ng	74.38	μg
Cl-*	Water	59.80	mg	30.26	g
Cl2*	Air	2.24	mg	1.13	g
CO*	Air	4.18	g	2.12	kg
CO2	Air	661.00	g	334.47	kg
CO2 (fossil)	Air	20.00	g	10.12	kg
CO2 (non-fossil)	Air	18.30	mg	9.26	g
coal	Raw	581.00	g	293.99	kg
cobalt*	Air	236.00	ng	119.42	μg
COD*	Water	8.58	mg	4.34	g
Cr	Water	59.70	μg	30.21	mg
Cr	Air	13.60	μg	6.88	mg
crude oil	Raw	7.96	g	4.03	g
CxHy aromatic	Air	432.00	mg	218.59	g
CxHy chloro	Air	21.50	mg	10.88	g
cyanide*	Water	89.60	ng	45.34	μg
dichloromethane	Air	14.10	mg	7.13	g
dioxin (TEQ)	Air	0.55	pg	0.28	ng
dissolved solids*	Water	1.30	g	0.66	kg
Douglas-fir logs*	Raw	1.70	kg	861.00	kg
energy from hydro power*	Raw	1,150.00	kJ	581.90	MJ
energy from oil	Raw	1.15	MJ	0.58	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
Fe*	Air	1,270.00	µg	642.62	mg
Fe*	Water	445.00	µg	225.17	mg
fluoride ions*	Water	21.20	µg	10.73	mg
formaldehyde	Air	64.40	mg	32.59	g
H2SO4*	Water	69.80	µg	35.32	mg
HCl*	Air	522.00	µg	264.13	mg
HF*	Air	72.20	µg	36.53	mg
Hg	Water	4.69	ng	2.37	µg
Hg	Air	217.00	ng	109.80	µg
K*	Air	224.00	mg	113.34	g
kerosene*	Air	5.32	µg	2.69	mg
limestone*	Raw	33.50	g	16.95	kg
metallic ions*	Water	88.50	µg	44.78	mg
metals	Air	7.30	µg	3.69	mg
methane	Air	178.00	mg	90.07	g
methanol	Air	108.00	mg	54.65	g
methyl bromide	Air	7.97	mg	4.03	g
methyl ethyl ketone	Air	17.60	mg	8.91	g
methyl i-butyl ketone	Air	36.90	mg	18.67	g
Mn*	Water	229.00	µg	115.87	mg
Mn*	Air	2.59	mg	1.31	g
n-nitrodimethylamine*	Air	22.00	ng	11.13	µg
N2O	Air	58.70	µg	29.70	mg
Na*	Air	5.18	mg	2.62	g
Na*	Water	8.43	µg	4.27	mg
naphthalene*	Air	690.00	µg	349.14	mg
natural gas (feedstock)	Raw	19.80	dm3	10,018.80	dm3
natural gas	Raw	25.70	g	13.00	kg
NH3*	Water	16.40	µg	8.30	mg
Ni	Air	164.00	µg	82.98	mg
nitrate*	Water	2,000.00	ng	1,012.00	µg
non methane VOC	Air	262.00	mg	132.57	g
NOx	Air	916.00	mg	463.50	g
o-xylene	Air	5.63	mg	2.85	g
oil*	Water	23.20	mg	11.74	g
organic substances*	Air	92.90	mg	47.01	g
other organics*	Water	3.80	mg	1.92	g
particulates*	Air	2.14	g	1.08	kg
Pb	Water	7.38	ng	3.73	µg
Pb	Air	345.00	µg	174.57	mg
phenol*	Water	288.00	ng	145.73	µg
phenol*	Air	94.70	mg	47.92	g
phosphate*	Water	35.10	µg	17.76	mg
radioactive substance to air*	Non mat.	121.00	Bq	61,226.00	Bq
Sb*	Air	94.30	ng	47.72	µg
Se*	Air	787.00	ng	398.22	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
SO_2	Air	46.30	mg	23.43	g
solid waste*	Solid	30.50	g	15.43	kg
SO_x	Air	921.00	mg	466.03	g
styrene	Air	8.80	mg	4.45	g
sulphate*	Water	49.50	mg	25.05	g
suspended solids*	Water	6.94	mg	3.51	g
tetrachloroethene	Air	99.30	ng	50.25	µg
tetrachloromethane	Air	156.00	ng	78.94	µg
toluene	Air	7.79	mg	3.94	g
trichloroethene	Air	98.30	ng	49.74	µg
uranium*	Raw	38.00	µg	19.23	mg
vinyl chloride	Air	7.82	mg	3.96	g
VOC	Air	54.60	mg	27.63	g
wood and wood wastes*	Raw	107.00	mg	54.14	g
xylene	Air	5.95	mg	3.01	g
Zn	Water	20.60	µg	10.42	mg
Zn	Air	1,270.00	µg	642.62	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood 3/8" Basis in the PNW for the base case using 100% natural gas for heating.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
1,2,4-trichlorobenzene	Air	15.40	mg	7.79	g
1,2-dichloroethane	Air	8.42	mg	4.26	g
acetaldehyde	Air	31.10	mg	15.74	g
acetone	Air	27.20	mg	13.76	g
Acid as H+*	Water	5.99	ng	3.03	μμg
acrolein	Air	16.10	mg	8.15	g
aldehydes	Air	21.00	mg	10.63	g
alkenes	Air	1,528.54	mg	773.44	g
ammonia	Air	68.00	μμg	34.41	μμg
As	Air	-2.52	μμg	-1.28	mg
B*	Water	518.00	μμg	262.11	mg
Ba*	Air	-168.00	μμg	-85.01	mg
Be*	Air	71.00	ng	35.93	μμg
benzene	Air	6.31	mg	3.19	g
BOD*	Water	9.69	mg	4.90	mg
Ca*	Water	5.75	μμg	2.91	mg
Cd	Water	458.00	μμg	231.75	mg
Cd	Air	954.00	ng	482.72	μμg
chromate*	Water	774.00	ng	391.64	μμg
Cl-*	Water	458.00	mg	231.75	g
Cl2*	Air	-297.00	μμg	-150.28	mg
CO*	Air	510.00	mg	258.06	g
CO2	Air	-23.30	g	-11.79	kg
CO2 (fossil)	Air	401.00	g	202.91	kg
CO2 (non-fossil)	Air	98.00	mg	49.59	g
coal	Raw	-72.50	g	-36.69	kg
cobalt*	Air	948.00	ng	479.69	μμg
COD*	Water	131.00	mg	66.29	g
Cr	Water	458.00	μμg	231.75	mg
Cr	Air	-0.72	μμg	-0.36	mg
crude oil	Raw	5.30	g	2.68	kg
CxHy aromatic	Air	432.00	mg	218.59	g
CxHy chloro	Air	21.50	mg	10.88	g
cyanide*	Water	687.00	ng	347.62	μμg
dichloromethane	Air	14.10	mg	7.13	g
dioxin (TEQ)	Air	0.87	pg	0.44	ng
dissolved solids*	Water	10.10	g	5.11	kg
Douglas-fir logs*	Raw	1.70	kg	861.00	kg
energy from hydro power*	Raw	1,150.00	kJ	581.90	MJ
energy from oil	Raw	1.15	MJ	0.58	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
Fe*	Air	-168.00	µg	-85.01	mg
Fe*	Water	653.00	µg	330.42	mg
fluoride ions*	Water	26.60	µg	13.46	mg
formaldehyde	Air	62.20	mg	31.47	g
H2SO4*	Water	130.00	µg	65.78	mg
HCl*	Air	801.00	µg	405.31	mg
HF*	Air	109.00	µg	55.15	mg
Hg	Water	36.00	ng	18.22	µg
Hg	Air	427.00	ng	216.06	µg
K*	Air	-29.80	mg	-15.08	g
kerosene*	Air	6.69	µg	3.39	mg
limestone*	Raw	-4.18	g	-2.12	g
metallic ions*	Water	128.00	µg	64.77	mg
metals	Air	38.60	µg	19.53	mg
methane	Air	1,270.00	mg	642.62	g
methanol	Air	108.00	mg	54.65	g
methyl bromide	Air	7.97	mg	4.03	g
methyl ethyl ketone	Air	17.60	mg	8.91	g
methyl i-butyl ketone	Air	36.90	mg	18.67	g
Mn*	Water	348.00	µg	176.09	mg
Mn*	Air	-342.00	µg	-173.05	mg
n-nitrodimethylamine*	Air	33.70	ng	17.05	µg
N2O	Air	92.80	µg	46.96	mg
Na*	Air	-688.00	µg	-348.13	mg
Na*	Water	10.60	µg	5.36	mg
naphthalene*	Air	-91.70	µg	-46.40	mg
natural gas (feedstock)	Raw	19.80	dm3	10,018.80	dm3
natural gas	Raw	190.00	g	96.14	g
NH3*	Water	184.00	µg	93.10	mg
Ni	Air	-7.91	µg	-4.00	mg
nitrate*	Water	2,510.00	ng	1,270.06	µg
non methane VOC	Air	1,800.00	mg	910.80	g
NOx	Air	1,420.00	mg	718.52	g
o-xylene	Air	5.63	mg	2.85	g
oil*	Water	177.00	mg	89.56	g
organic substances*	Air	41.30	mg	20.90	g
other organics*	Water	28.90	mg	14.62	g
particulates*	Air	2.12	g	1.07	kg
Pb	Water	10.50	ng	5.31	µg
Pb	Air	-44.70	µg	-22.62	mg
phenol*	Water	413.00	ng	208.98	µg
phenol*	Air	81.70	mg	41.34	g
phosphate*	Water	66.40	µg	33.60	mg
radioactive substance to air*	Non mat.	204.00	Bq	103,224.00	Bq
Sb*	Air	348.00	ng	176.09	ng
Se*	Air	1,410.00	ng	713.46	ng

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
SO2	Air	46.30	mg	23.43	g
solid waste*	Solid	16.70	g	8.45	kg
SOx	Air	6.71	g	3.40	kg
styrene	Air	8.80	mg	4.45	g
sulphate*	Water	363.00	mg	183.68	g
suspended solids*	Water	165.00	mg	83.49	g
tetrachloroethene	Air	156.00	ng	78.94	µg
tetrachloromethane	Air	469.00	ng	237.31	µg
toluene	Air	7.79	mg	3.94	g
trichloroethene	Air	150.00	ng	75.90	µg
uranium*	Raw	28.60	µg	14.47	mg
vinyl chloride	Air	7.82	mg	3.96	g
VOC	Air	54.60	mg	27.63	g
wood and wood wastes*	Raw	68.20	mg	34.51	g
xylene	Air	5.95	mg	3.01	g
Zn	Water	157.00	µg	79.44	mg
Zn	Air	-168.00	µg	-85.01	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of plywood in the Southern region for the base case.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
1,2,4-trichlorobenzene	Air	6.86	mg	3.97	g
1,2-dichloroethane	Air	3.77	mg	2.18	g
acetaldehyde	Air	42.40	mg	24.55	g
acetone	Air	60.00	mg	34.74	g
Acid as H+*	Water	8.40	ng	4.86	µg
acrolein	Air	17.80	mg	10.31	g
aldehydes	Air	11.20	mg	6.48	g
alkenes	Air	3,228.56	mg	1,869.34	g
ammonia	Air	225.00	µg	130.28	mg
As	Air	18.20	µg	10.54	mg
B*	Water	5.34	mg	3.09	g
Ba*	Air	676.00	µg	391.40	mg
Be*	Air	569.00	ng	329.45	µg
benzene	Air	9.05	mg	5.24	g
BOD*	Water	5.58	mg	3.23	g
Ca*	Water	20.60	µg	11.93	mg
Cd	Water	263.00	µg	152.28	mg
Cd	Air	1,100.00	ng	636.90	µg
chromate*	Water	793.00	ng	459.15	µg
Cl-*	Water	264.00	mg	152.86	g
Cl2*	Air	1,200.00	mg	694.80	g
CO*	Air	2.83	g	1.64	kg
CO2	Air	378.00	g	218.86	kg
CO2 (fossil)	Air	343.00	g	198.60	kg
CO2 (non-fossil)	Air	87.80	mg	50.84	g
coal	Raw	368.00	g	213.07	kg
cobalt*	Air	2.39	µg	1.38	mg
COD*	Water	71.40	mg	41.34	g
Cr	Water	263.00	µg	152.28	mg
Cr	Air	13.80	µg	7.99	mg
crude oil	Raw	10.30	g	5.96	kg
CxHy aromatic	Air	192.00	mg	111.17	g
CxHy chloro	Air	6.10	mg	3.53	g
cyanide*	Water	395.00	ng	228.71	µg
dichloromethane	Air	3.22	mg	1.86	g
dioxin (TEQ)	Air	11.30	pg	6.54	ng
dissolved solids*	Water	5.79	g	3.35	g
energy from hydro power*	Raw	41.40	kJ	23.97	MJ
energy from oil	Raw	1.13	MJ	0.65	GJ

* Denotes substance not defined by Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
Fe*	Air	676.00	µg	391.40	mg
Fe*	Water	7.49	mg	4.34	g
fluoride ions*	Water	95.20	µg	55.12	mg
formaldehyde	Air	127.00	mg	73.53	g
H2SO4*	Water	1,330.00	µg	770.07	mg
HCl*	Air	10.70	mg	6.20	g
HF*	Air	1.48	mg	0.86	g
Hg	Water	20.70	ng	11.99	µg
Hg	Air	4.06	µg	2.35	mg
K*	Air	120.00	mg	69.48	g
kerosene*	Air	23.90	µg	13.84	mg
limestone*	Raw	21.20	g	12.27	kg
metallic ions*	Water	179.00	µg	103.64	mg
metals	Air	34.90	µg	20.21	mg
methane	Air	1,020.00	mg	590.58	g
methanol	Air	181.00	mg	104.80	g
methyl bromide	Air	3.58	mg	2.07	g
methyl ethyl ketone	Air	9.51	mg	5.51	g
methyl i-butyl ketone	Air	8.54	mg	4.94	g
Mn*	Water	4.60	mg	2.66	g
Mn*	Air	1,400.00	mg	810.60	g
n-nitrodimethylamine*	Air	449.00	ng	259.97	µg
N2O	Air	1,190.00	µg	689.01	mg
Na*	Air	2.76	mg	1.60	g
Na*	Water	37.80	µg	21.89	mg
naphthalene*	Air	369.00	µg	213.65	mg
natural gas (feedstock)	Raw	19.40	dm3	11,232.60	dm3
natural gas FAL	Raw	110.00	g	63.69	kg
NH3*	Water	134.00	µg	77.59	mg
Ni	Air	103.00	µg	59.64	mg
nitrate*	Water	8.97	µg	5.19	mg
non methane VOC	Air	1,070.00	mg	619.53	g
NOx	Air	1,710.00	mg	990.09	g
o-xylene	Air	3.84	mg	2.22	g
oil*	Water	102.00	mg	59.06	g
organic substances*	Air	71.50	mg	41.40	g
other organics*	Water	17.50	mg	10.13	g
particulates*	Air	2.11	g	1.22	kg
Pb	Water	14.90	ng	8.63	µg
Pb	Air	271.00	µg	156.91	mg
phenol*	Water	580.00	ng	335.82	µg
phenol*	Air	81.50	mg	47.19	g
phosphate*	Water	668.00	µg	386.77	mg
radioactive substance to air*	Non mat.	2,060.00	Bq	1,192,740.00	Bq
Sb*	Air	1,060.00	ng	613.74	µg
Se*	Air	15.10	µg	8.74	mg

* Denotes substance not defined by Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of plywood:	Unit:
SO2	Air	45.40	mg	26.29	g
solid waste*	Solid	50.30	g	29.12	kg
Southern Yellow Pine logs*	Raw	1.50	kg	871.00	kg
SOx	Air	4.65	g	2.69	kg
styrene	Air	4.13	mg	2.39	g
sulphate*	Water	218.00	mg	126.22	g
suspended solids*	Water	173.00	mg	100.17	g
tetrachloroethene	Air	2.02	µg	1.17	mg
tetrachloromethane	Air	2.56	µg	1.48	mg
toluene	Air	10.30	mg	5.96	g
trichloroethene	Air	2.01	µg	1.16	mg
uranium*	Raw	116.00	µg	67.16	mg
vinyl chloride	Air	2.35	mg	1.36	g
VOC	Air	53.50	mg	30.98	g
wood and wood wastes*	Raw	116.00	mg	67.16	g
xylene	Air	6.64	mg	3.84	g
Zn	Water	90.40	µg	52.34	mg
Zn	Air	676.00	µg	391.40	mg

* Denotes substance not defined by Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood 3/8" basis in the Southern region for the base case without a RTO.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
1,2,4-trichlorobenzene	Air	7.58	mg	4.39	g
1,2-dichloroethane	Air	4.14	mg	2.40	g
acetaldehyde	Air	58.90	mg	34.10	g
acetone	Air	78.20	mg	45.28	g
Acid as H+*	Water	8.28	ng	4.79	µg
acrolein	Air	18.80	mg	10.89	g
aldehydes	Air	11.90	mg	6.89	g
alkenes	Air	5.86	g	3.39	g
ammonia	Air	217.00	µg	125.64	mg
As	Air	17.80	µg	10.31	mg
B*	Water	5.26	mg	3.05	g
Ba*	Air	658.00	µg	380.98	mg
Be*	Air	560.00	ng	324.24	µg
benzene	Air	9.75	mg	5.65	g
BOD*	Water	5.47	mg	3.17	g
Ca*	Water	19.80	µg	11.46	mg
Cd	Water	258.00	µg	149.38	mg
Cd	Air	1,080.00	ng	625.32	µg
chromate*	Water	771.00	ng	446.41	µg
Cl-*	Water	259.00	mg	149.96	g
Cl2*	Air	1,170.00	mg	677.43	g
CO*	Air	2.73	g	1.58	kg
CO2	Air	370.00	g	214.23	kg
CO2 (fossil)	Air	336.00	g	194.54	kg
CO2 (non-fossil)	Air	86.00	mg	49.79	g
coal	Raw	359.00	g	207.86	kg
cobalt*	Air	2.35	µg	1.36	mg
COD*	Water	69.90	mg	40.47	g
Cr	Water	258.00	µg	149.38	mg
Cr	Air	13.50	µg	7.82	mg
crude oil	Raw	10.10	g	5.85	kg
CxHy aromatic	Air	213.00	mg	123.33	g
CxHy chloro	Air	6.75	mg	3.91	g
cyanide*	Water	387.00	ng	224.07	µg
dichloromethane	Air	3.55	mg	2.06	g
dioxin (TEQ)	Air	11.10	pg	6.43	ng
dissolved solids*	Water	5.68	g	3.29	kg
energy from hydro power*	Raw	39.60	kJ	22.93	MJ
energy from oil	Raw	1.13	MJ	0.65	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
ethane	Air	1.76	mg	1.02	g
Fe*	Air	658.00	µg	380.98	mg
Fe*	Water	7.38	mg	4.27	g
fluoride ions*	Water	91.70	µg	53.09	mg
formaldehyde	Air	138.00	mg	79.90	g
H2SO4*	Water	1,320.00	µg	764.28	mg
HCl*	Air	10.50	mg	6.08	g
HF*	Air	1.46	mg	0.85	g
Hg	Water	20.30	ng	11.75	µg
Hg	Air	4.00	µg	2.32	mg
K*	Air	117.00	mg	67.74	g
kerosene*	Air	23.00	µg	13.32	mg
limestone*	Raw	20.70	g	11.99	kg
metallic ions*	Water	176.00	µg	101.90	mg
metals	Air	34.20	µg	19.80	mg
methane	Air	984.00	mg	569.74	g
methanol	Air	231.00	mg	133.75	g
methyl bromide	Air	3.97	mg	2.30	g
methyl ethyl ketone	Air	10.40	mg	6.02	g
methyl i-butyl ketone	Air	9.45	mg	5.47	g
Mn*	Water	4.54	mg	2.63	g
Mn*	Air	1,360.00	mg	787.44	g
n-nitrodimethylamine*	Air	443.00	ng	256.50	µg
N2O	Air	1,170.00	µg	677.43	mg
Na*	Air	2.69	mg	1.56	g
Na*	Water	36.40	µg	21.08	mg
naphthalene*	Air	359.00	µg	207.86	mg
natural gas (feedstock)	Raw	19.40	dm3	11,232.60	dm3
natural gas	Raw	107.00	g	61.95	kg
NH3*	Water	131.00	µg	75.85	mg
Ni	Air	100.00	µg	57.90	mg
nitrate*	Water	8.64	µg	5.00	mg
non methane VOC	Air	1,050.00	mg	607.95	g
NOx	Air	1,680.00	mg	972.72	g
o-xylene	Air	4.29	mg	2.48	g
oil*	Water	99.80	mg	57.78	g
organic substances*	Air	70.80	mg	40.99	g
other organics*	Water	17.20	mg	9.96	g
particulates*	Air	3.02	g	1.75	kg
Pb	Water	14.70	ng	8.51	µg
Pb	Air	264.00	µg	152.86	mg
phenol*	Water	572.00	ng	331.19	µg
phenol*	Air	81.10	mg	46.96	g
phosphate*	Water	659.00	µg	381.56	mg
radioactive substance to air*	Non mat.	2,020.00	Bq	1,169,580.00	Bq
Sb*	Air	1,050.00	ng	607.95	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
Se*	Air	14.90	µg	8.63	mg
SO2	Air	45.40	mg	26.29	g
solid waste*	Solid	49.30	g	28.54	kg
Southern Yellow Pine logs*	Raw	1.50	kg	871.00	kg
SOx	Air	4.56	g	2.64	kg
styrene	Air	4.55	mg	2.63	g
sulphate*	Water	214.00	mg	123.91	g
suspended solids*	Water	170.00	mg	98.43	g
tetrachloroethene	Air	1.99	µg	1.15	mg
tetrachloromethane	Air	2.52	µg	1.46	mg
toluene	Air	10.70	mg	6.20	g
trichloroethene	Air	1.98	µg	1.15	mg
uranium*	Raw	112.00	µg	64.85	mg
vinyl chloride	Air	2.60	mg	1.51	g
VOC	Air	53.50	mg	30.98	g
wood and wood wastes*	Raw	114.00	mg	66.01	g
xylene	Air	7.08	mg	4.10	g
Zn	Water	88.70	µg	51.36	mg
Zn	Air	658.00	µg	380.98	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood 3/8" basis in the Southern region for the base case with one direct-natural gas-fired dryer and onw indirect steam heated dryer fed into a RCO.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
1,2,4-trichlorobenzene	Air	7.65	mg	4.43	g
1,2-dichloroethane	Air	4.13	mg	2.39	g
acetaldehyde	Air	89.00	mg	51.53	g
acetone	Air	96.70	mg	55.99	g
Acid as H+*	Water	7.90	ng	4.57	µg
acrolein	Air	18.40	mg	10.65	g
aldehydes	Air	12.10	mg	7.01	g
alkenes	Air	3.29	g	1.90	g
ammonia	Air	223.00	µg	129.12	mg
As	Air	14.10	µg	8.16	mg
B*	Water	5.35	mg	3.10	g
Ba*	Air	466.00	µg	269.81	mg
Be*	Air	565.00	ng	327.14	µg
benzene	Air	9.63	mg	5.58	g
BOD*	Water	6.70	mg	3.88	g
Ca*	Water	20.50	µg	11.87	mg
Cd	Water	316.00	µg	182.96	mg
Cd	Air	1,160.00	ng	671.64	µg
chromate*	Water	864.00	ng	500.26	µg
Cl-*	Water	317.00	mg	183.54	g
Cl2*	Air	828.00	µg	479.41	mg
CO*	Air	2,240.00	g	1,296.96	kg
CO2	Air	278.00	g	160.96	kg
CO2 (fossil)	Air	391.00	g	226.39	kg
CO2 (non-fossil)	Air	97.70	mg	56.57	g
coal	Raw	272.00	g	157.49	kg
cobalt*	Air	2.47	µg	1.43	mg
COD*	Water	87.70	mg	50.78	g
Cr	Water	316.00	µg	182.96	mg
Cr	Air	11.50	µg	6.66	mg
crude oil	Raw	9.22	g	5.34	kg
CxHy aromatic	Air	214.00	mg	123.91	g
CxHy chloro	Air	6.77	mg	3.92	g
cyanide*	Water	474.00	ng	274.45	µg
dichloromethane	Air	3.61	mg	2.09	g
dioxin (TEQ)	Air	11.30	pg	6.54	ng
dissolved solids*	Water	6.96	g	4.03	kg
energy from hydro power*	Raw	41.00	kJ	23.74	MJ
energy from oil	Raw	1.13	MJ	0.65	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
ethane	Air	7.05	mg	4.08	g
Fe*	Air	466.00	µg	269.81	mg
Fe*	Water	7.50	mg	4.34	g
fluoride ions*	Water	95.10	µg	55.06	mg
formaldehyde	Air	155.00	mg	89.75	g
H2SO4*	Water	1,340.00	µg	775.86	mg
HCl*	Air	10.70	mg	6.20	g
HF*	Air	1.48	mg	0.86	g
Hg	Water	24.80	ng	14.36	µg
Hg	Air	4.06	µg	2.35	mg
K*	Air	82.60	mg	47.83	g
kerosene*	Air	23.90	µg	13.84	mg
limestone*	Raw	15.70	g	9.09	kg
metallic ions*	Water	169.00	µg	97.85	mg
metals	Air	38.80	µg	22.47	mg
methane	Air	1,210.00	mg	700.59	g
methanol	Air	183.00	mg	105.96	g
methyl bromide	Air	3.98	mg	2.30	g
methyl ethyl ketone	Air	10.40	mg	6.02	g
methyl i-butyl ketone	Air	9.40	mg	5.44	g
Mn*	Water	4.61	mg	2.67	g
Mn*	Air	968.00	µg	560.47	mg
n-nitrodimethylamine*	Air	450.00	ng	260.55	µg
N2O	Air	1,190.00	µg	689.01	mg
Na*	Air	1,910.00	mg	1,105.89	g
Na*	Water	37.80	µg	21.89	mg
naphthalene*	Air	254.00	µg	147.07	mg
natural gas (feedstock)	Raw	19.40	dm3	11,232.60	dm3
natural gas	Raw	131.00	g	75.85	kg
NH3*	Water	155.00	µg	89.75	mg
Ni	Air	77.40	µg	44.81	mg
nitrate*	Water	8.97	µg	5.19	mg
non methane VOC	Air	1,270.00	mg	735.33	g
NOx	Air	1,760.00	mg	1,019.04	g
o-xylene	Air	4.27	mg	2.47	g
oil*	Water	122.00	mg	70.64	g
organic substances*	Air	63.90	mg	37.00	g
other organics*	Water	20.90	mg	12.10	g
particulates*	Air	2.10	g	1.22	kg
Pb	Water	14.00	ng	8.11	µg
Pb	Air	193.00	µg	111.75	mg
phenol*	Water	546.00	ng	316.13	µg
phenol*	Air	80.70	mg	46.73	g
phosphate*	Water	670.00	µg	387.93	mg
radioactive substance to air*	Non mat.	2,060.00	Bq	1,192,740.00	Bq
Sb*	Air	1,090.00	ng	631.11	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
Se*	Air	15.10	µg	8.74	mg
SO2	Air	45.40	mg	26.29	g
solid waste*	Solid	47.90	g	27.73	kg
Southern Yellow Pine logs*	Raw	1.50	kg	871.00	kg
SOx	Air	5.42	g	3.14	kg
styrene	Air	4.55	mg	2.63	g
sulphate*	Water	260.00	mg	150.54	g
suspended solids*	Water	193.00	mg	111.75	g
tetrachloroethene	Air	2.02	µg	1.17	mg
tetrachloromethane	Air	2.59	µg	1.50	mg
toluene	Air	10.70	mg	6.20	g
trichloroethene	Air	2.01	µg	1.16	mg
uranium*	Raw	113.00	µg	65.43	mg
vinyl chloride	Air	2.61	mg	1.51	g
VOC	Air	53.50	mg	30.98	g
wood and wood wastes*	Raw	109.00	mg	63.11	g
xylene	Air	7.06	mg	4.09	g
Zn	Water	109.00	µg	63.11	mg
Zn	Air	466.00	µg	269.81	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood 3/8" basis in the Southern region for the base case using 100% hog fuel for heating.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
1,2,4-trichlorobenzene	Air	6.86	mg	3.97	g
1,2-dichloroethane	Air	3.77	mg	2.18	g
acetaldehyde	Air	42.90	mg	24.84	g
acetone	Air	60.00	mg	34.74	g
Acid as H+*	Water	4.47	ng	2.59	µg
acrolein	Air	17.80	mg	10.31	g
aldehydes	Air	10.50	mg	6.08	g
alkenes	Air	3.23	g	1.87	g
ammonia	Air	197.00	µg	114.06	mg
As	Air	32.70	µg	18.93	mg
B*	Water	5.21	mg	3.02	g
Ba*	Air	1,420.00	µg	822.18	mg
Be*	Air	514.00	ng	297.61	µg
benzene	Air	9.66	mg	5.59	g
BOD*	Water	1.30	mg	0.75	g
Ca*	Water	19.90	µg	11.52	mg
Cd	Water	64.20	µg	37.17	mg
Cd	Air	527.00	ng	305.13	µg
chromate*	Water	446.00	ng	258.23	µg
Cl-*	Water	64.70	mg	37.46	g
Cl2*	Air	2.51	mg	1.45	g
CO*	Air	4.73	g	2.74	kg
CO2	Air	732.00	g	423.83	kg
CO2 (fossil)	Air	145.00	g	83.96	kg
CO2 (non-fossil)	Air	45.90	mg	26.58	g
coal	Raw	706.00	g	408.77	kg
cobalt*	Air	1.99	µg	1.15	mg
COD*	Water	10.20	mg	5.91	g
Cr	Water	64.20	µg	37.17	mg
Cr	Air	20.50	µg	11.87	mg
crude oil	Raw	8.96	g	5.19	kg
CxHy aromatic	Air	192.00	mg	111.17	g
CxHy chloro	Air	6.10	mg	3.53	g
cyanide*	Water	96.20	ng	55.70	µg
dichloromethane	Air	3.22	mg	1.86	g
dioxin (TEQ)	Air	11.10	pg	6.43	ng
dissolved solids*	Water	1.40	g	0.81	kg
energy from hydro power*	Raw	41.40	kJ	23.97	MJ
energy from oil	Raw	1.13	MJ	0.65	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
Fe*	Air	1,420.00	µg	822.18	mg
Fe*	Water	7.38	mg	4.27	g
fluoride ions*	Water	92.30	µg	53.44	mg
formaldehyde	Air	128.00	mg	74.11	g
H2SO4*	Water	1,300.00	µg	752.70	mg
HCl*	Air	10.50	mg	6.08	g
HF*	Air	1.46	mg	0.85	g
Hg	Water	5.04	ng	2.92	µg
Hg	Air	3.90	µg	2.26	mg
K*	Air	251.00	mg	145.33	g
kerosene*	Air	23.20	µg	13.43	mg
limestone*	Raw	40.70	g	23.57	kg
metallic ions*	Water	95.00	µg	55.01	mg
metals	Air	18.40	µg	10.65	mg
methane	Air	474.00	mg	274.45	g
methanol	Air	181.00	mg	104.80	g
methyl bromide	Air	3.58	mg	2.07	g
methyl ethyl ketone	Air	9.51	mg	5.51	g
methyl i-butyl ketone	Air	8.54	mg	4.94	g
Mn*	Water	4.54	mg	2.63	g
Mn*	Air	2.91	mg	1.68	g
n-nitrodimethylamine*	Air	443.00	ng	256.50	µg
N2O	Air	1,170.00	µg	677.43	mg
Na*	Air	5.79	mg	3.35	g
Na*	Water	36.70	µg	21.25	mg
naphthalene*	Air	772.00	µg	446.99	mg
natural gas (feedstock)	Raw	19.40	dm3	11,232.60	dm3
natural gas	Raw	27.60	g	15.98	kg
NH3*	Water	45.80	µg	26.52	mg
Ni	Air	191.00	µg	110.59	mg
nitrate*	Water	8.71	µg	5.04	mg
non methane VOC	Air	285.00	mg	165.02	g
NOx	Air	1,460.00	mg	845.34	g
o-xylene	Air	3.84	mg	2.22	g
oil*	Water	24.90	mg	14.42	g
organic substances*	Air	98.10	mg	56.80	g
other organics*	Water	5.03	mg	2.91	g
particulates*	Air	2.12	g	1.23	kg
Pb	Water	7.92	ng	4.59	µg
Pb	Air	392.00	µg	226.97	mg
phenol*	Water	309.00	ng	178.91	µg
phenol*	Air	88.20	mg	51.07	g
phosphate*	Water	651.00	µg	376.93	mg
radioactive substance to air*	Non mat.	2,020.00	Bq	1,169,580.00	Bq
Sb*	Air	924.00	ng	535.00	µg
Se*	Air	14.70	µg	8.51	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
SO2	Air	45.40	mg	26.29	g
solid waste*	Solid	57.60	g	33.35	kg
Southern Yellow Pine logs*	Raw	1.50	kg	871.00	kg
SOx	Air	1.75	g	1.01	kg
styrene	Air	4.13	mg	2.39	g
sulphate*	Water	61.80	mg	35.78	g
suspended solids*	Water	93.90	mg	54.37	g
tetrachloroethene	Air	1.99	µg	1.15	mg
tetrachloromethane	Air	2.40	µg	1.39	mg
toluene	Air	10.30	mg	5.96	g
trichloroethene	Air	1.98	µg	1.15	mg
uranium*	Raw	120.00	µg	69.48	mg
vinyl chloride	Air	2.35	mg	1.36	g
VOC	Air	53.50	mg	30.98	g
wood and wood wastes*	Raw	136.00	mg	78.74	g
xylene	Air	6.64	mg	3.84	g
Zn	Water	22.10	µg	12.80	mg
Zn	Air	1,420.00	µg	822.18	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of plywood 3/8" basis in the Southern region for the base case using 100% Natural Gas for heating.

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
1,2,4-trichlorobenzene	Air	6.86	mg	3.97	g
1,2-dichloroethane	Air	3.77	mg	2.18	g
acetaldehyde	Air	41.90	mg	24.26	g
acetone	Air	60.00	mg	34.74	g
Acid as H+*	Water	6.35	ng	3.68	µg
acrolein	Air	17.80	mg	10.31	g
aldehydes	Air	11.50	mg	6.66	g
alkenes	Air	3,228.56	mg	1,869.34	g
ammonia	Air	225.00	µg	130.28	mg
As	Air	3.66	µg	2.12	mg
B*	Water	5.45	mg	3.16	g
Ba*	Air	-62.00	µg	-35.90	mg
Be*	Air	555.00	ng	321.35	µg
benzene	Air	8.45	mg	4.89	g
BOD*	Water	10.00	mg	5.79	g
Ca*	Water	21.10	µg	12.22	mg
Cd	Water	475.00	µg	275.03	mg
Cd	Air	1,320.00	ng	764.28	µg
chromate*	Water	1,090.00	ng	631.11	µg
Cl-*	Water	476.00	mg	275.60	g
Cl2*	Air	-108.00	µg	-62.53	mg
CO*	Air	950.00	mg	550.05	g
CO2	Air	26.30	g	15.23	kg
CO2 (fossil)	Air	537.00	g	310.92	kg
CO2 (non-fossil)	Air	128.00	mg	74.11	g
coal	Raw	31.50	g	18.24	kg
cobalt*	Air	2.73	µg	1.58	mg
COD*	Water	136.00	mg	78.74	g
Cr	Water	475.00	µg	275.03	mg
Cr	Air	5.69	µg	3.29	mg
crude oil	Raw	6.23	g	3.61	kg
CxHy aromatic	Air	192.00	mg	111.17	g
CxHy chloro	Air	6.10	mg	3.53	g
cyanide*	Water	713.00	ng	412.83	µg
dichloromethane	Air	3.22	mg	1.86	g
dioxin (TEQ)	Air	11.50	pg	6.66	ng
dissolved solids*	Water	10.50	g	6.08	kg
energy from hydro power*	Raw	41.40	kJ	23.97	MJ
energy from oil	Raw	1.13	MJ	0.65	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
Fe*	Air	-62.00	µg	-35.90	mg
Fe*	Water	7.60	mg	4.40	g
fluoride ions*	Water	97.90	µg	56.68	mg
formaldehyde	Air	126.00	mg	72.95	g
H2SO4*	Water	1.36	mg	0.79	g
HCl*	Air	10.80	mg	6.25	g
HF*	Air	1.50	mg	0.87	g
Hg	Water	37.30	ng	21.60	µg
Hg	Air	4.12	µg	2.39	mg
K*	Air	-11.00	mg	-6.37	g
kerosene*	Air	24.60	µg	14.24	mg
limestone*	Raw	1.82	g	1.05	kg
metallic ions*	Water	136.00	µg	78.74	mg
metals	Air	50.70	µg	29.36	mg
methane	Air	1,600.00	mg	926.40	g
methanol	Air	181.00	mg	104.80	g
methyl bromide	Air	3.58	mg	2.07	g
methyl ethyl ketone	Air	9.51	mg	5.51	g
methyl i-butyl ketone	Air	8.54	mg	4.94	g
Mn*	Water	4.66	mg	2.70	g
Mn*	Air	-112.00	µg	-64.85	mg
n-nitrodimethylamine*	Air	455.00	ng	263.45	mg
N2O	Air	1,210.00	µg	700.59	mg
Na*	Air	-254.00	µg	-147.07	mg
Na*	Water	38.90	µg	22.52	mg
naphthalene*	Air	-33.70	µg	-19.51	mg
natural gas (feedstock)	Raw	19.40	dm3	11,232.60	dm3
natural gas	Raw	197.00	g	114.06	kg
NH3*	Water	219.00	µg	126.80	mg
Ni	Air	14.00	µg	8.11	mg
nitrate	Water	9.23	µg	5.34	mg
non methane VOC	Air	1,870.00	mg	1,082.73	g
NOx	Air	1,970.00	mg	1,140.63	g
o-xylene	Air	3.84	mg	2.22	g
oil*	Water	183.00	mg	105.96	g
organic substances*	Air	44.90	mg	26.00	g
other organics*	Water	30.90	mg	17.89	g
particulates*	Air	2.10	g	1.22	g
Pb	Water	11.10	ng	6.43	µg
Pb	Air	-10.20	µg	-5.91	mg
phenol*	Water	438.00	ng	253.60	µg
phenol*	Air	74.80	mg	43.31	g
phosphate*	Water	683.00	µg	395.46	mg
radioactive substance to air*	Non mat.	2,100.00	Bq	1,215,900.00	Bq
Sb*	Air	1,190.00	ng	689.01	µg
Se*	Air	15.40	µg	8.92	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of plywood:	Unit:	per MSF of Plywood:	Unit:
SO2	Air	45.40	mg	26.29	g
solid waste*	Solid	43.40	g	25.13	kg
Southern Yellow Pine logs*	Raw	1.50	kg	871.00	kg
SOx	Air	7.72	g	4.47	kg
styrene	Air	4.13	mg	2.39	g
sulphate*	Water	385.00	mg	222.92	g
suspended solids*	Water	256.00	mg	148.22	g
tetrachloroethene	Air	2.05	µg	1.19	mg
tetrachloromethane	Air	2.72	µg	1.57	mg
toluene	Air	10.30	mg	5.96	g
trichloroethene	Air	2.04	µg	1.18	mg
uranium*	Raw	111.00	µg	64.27	mg
vinyl chloride	Air	2.35	mg	1.36	g
VOC	Air	53.50	mg	30.98	g
wood and wood wastes*	Raw	95.70	mg	55.41	g
xylene	Air	6.64	mg	3.84	g
Zn	Water	163.00	µg	94.38	mg
Zn	Air	-62.00	µg	-35.90	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MCF of LVL in the PNW for the base case.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	14.90	mg	249.41	g
1,2-dichloroethane	Air	8.16	mg	136.59	g
acetaldehyde	Air	30.80	mg	515.56	g
acetone	Air	26.30	mg	440.24	g
Acid as H+*	Water	11.20	ng	187.48	µg
acrolein	Air	15.70	mg	262.80	g
aldehydes	Air	20.70	mg	346.50	g
alkenes	Air	1,488.58	mg	24,917.34	g
ammonia	Air	78.90	µg	1,320.71	mg
As	Air	18.00	µg	301.30	mg
B*	Water	379.00	µg	6,344.08	mg
Ba*	Air	866.00	µg	14,495.97	mg
Be*	Air	120.00	ng	2,008.68	µg
benzene	Air	7.00	mg	117.17	g
BOD*	Water	3.66	mg	61.26	g
Ca*	Water	4.96	µg	83.03	mg
Cd	Water	174.00	µg	2,912.59	mg
Cd	Air	817.00	ng	13,675.76	µg
chromate*	Water	402.00	ng	6,729.08	µg
Cl-*	Water	174.00	mg	2,912.59	g
Cl2*	Air	1.54	mg	25.78	g
CO*	Air	3.21	g	53.73	kg
CO2	Air	495.00	g	8,285.81	kg
CO2 (fossil)	Air	124.00	g	2,075.64	kg
CO2 (non-fossil)	Air	45.70	mg	764.97	g
coal	Raw	400.00	g	6,695.60	kg
cobalt*	Air	526.00	ng	8,804.71	µg
COD*	Water	39.70	mg	664.54	g
Cr	Water	174.00	µg	2,912.59	mg
Cr	Air	11.40	µg	190.82	mg
crude oil	Raw	13.10	g	219.28	kg
CxHy aromatic	Air	419.00	mg	7,013.64	g
CxHy chloro	Air	20.80	mg	348.17	g
cyanide*	Water	261.00	ng	4,368.88	µg
Douglas-fir logs*	Raw	1.67	kg	27,562.00	kg
dichloromethane	Air	13.60	mg	227.65	g
dioxin (TEQ)	Air	0.69	pg	11.47	ng
dissolved solids*	Water	3.82	g	63.94	kg
energy from hydro power*	Raw	1,170.00	kJ	19,584.63	MJ
energy from oil	Raw	1.66	MJ	27.79	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Fe*	Air	866.00	µg	14,495.97	mg
Fe*	Water	532.00	µg	8,905.15	mg
fluoride ions*	Water	22.90	µg	383.32	mg
formaldehyde	Air	84.40	mg	1,412.77	g
H2SO4*	Water	94.80	µg	1,586.86	mg
HCl*	Air	643.00	µg	10,763.18	mg
HF*	Air	88.30	µg	1,478.05	mg
Hg	Water	13.70	ng	229.32	µg
Hg	Air	393.00	ng	6,578.43	µg
K*	Air	154.00	mg	2,577.81	g
kerosene*	Air	5.76	µg	96.42	mg
limestone*	Raw	23.00	g	385.00	kg
metallic ions*	Water	238.00	µg	3,983.88	mg
metals	Air	18.20	µg	304.65	mg
methane	Air	493.00	mg	8,252.33	g
methanol	Air	105.00	mg	1,757.60	g
methyl bromide	Air	7.80	mg	130.56	g
methyl ethyl ketone	Air	17.10	mg	286.24	g
methyl i-butyl ketone	Air	35.70	mg	597.58	g
Mn*	Water	279.00	µg	4,670.18	mg
Mn*	Air	1.77	mg	29.63	g
n-nitrodimethylamine*	Air	27.00	ng	451.95	µg
N2O	Air	73.00	µg	1,221.95	mg
Na*	Air	3.54	mg	59.26	g
Na*	Water	9.12	µg	152.66	mg
naphthalene*	Air	472.00	µg	7,900.81	mg
natural gas (feedstock)	Raw	28.40	dm3	475,387.60	dm3
natural gas	Raw	72.70	g	1,216.93	kg
NH3*	Water	65.10	µg	1,089.71	mg
Ni	Air	118.00	µg	1,975.20	mg
nitrate*	Water	2,160.00	ng	36,156.24	µg
non methane VOC	Air	742.00	mg	12,420.34	g
NOx	Air	961.00	mg	16,086.18	g
o-xylene	Air	5.46	mg	91.39	g
oil*	Water	67.50	mg	1,129.88	g
organic substances*	Air	98.20	mg	1,643.77	g
other organics*	Water	11.00	mg	184.13	g
particulates*	Air	2.14	g	35.82	kg
Pb	Water	19.80	ng	331.43	µg
Pb	Air	314.00	µg	5,256.05	mg
phenol*	Water	772.00	ng	12,922.51	mg
phenol*	Air	118.00	mg	1,975.20	g
phosphate*	Water	48.10	µg	805.15	mg
radioactive substance to air*	Non mat.	152.00	Bq	2,544,328.00	Bq
Sb*	Air	198.00	ng	3,314.32	µg
Se*	Air	1,050.00	ng	17,575.95	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
SO2	Air	66.40	mg	1,111.47	g
solid waste*	Solid	26.90	g	450.28	kg
SOx	Air	2.59	g	43.35	kg
styrene	Air	8.53	mg	142.78	g
sulphate*	Water	139.00	mg	2,326.72	g
suspended solids*	Water	43.50	mg	728.15	g
tetrachloroethene	Air	123.00	ng	2,058.90	µg
tetrachloromethane	Air	264.00	ng	4,419.10	µg
toluene	Air	7.55	mg	126.38	g
trichloroethene	Air	120.00	ng	2,008.68	µg
uranium*	Raw	35.60	µg	595.91	mg
vinyl chloride	Air	7.58	mg	126.88	g
VOC	Air	78.30	mg	1,310.66	g
wood and wood wastes*	Raw	101.00	mg	1,690.64	g
xylene	Air	5.77	mg	96.58	g
Zn	Water	59.90	µg	1,002.67	mg
Zn	Air	866.00	µg	14,495.97	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MCF of LVL in the PNW for the base case without the WESP.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	15.10	mg	252.76	g
1,2-dichloroethane	Air	8.26	mg	138.26	g
acetaldehyde	Air	30.80	mg	515.56	g
acetone	Air	34.00	mg	569.13	g
Acid as H+*	Water	11.20	ng	187.48	µg
acrolein	Air	13.00	mg	217.61	g
aldehydes	Air	20.80	mg	348.17	g
alkenes	Air	1,440.00	mg	24,104.16	g
ammonia	Air	78.20	µg	1,308.99	mg
As	Air	18.00	µg	301.30	mg
B*	Water	372.00	µg	6,226.91	mg
Ba*	Air	866.00	µg	14,495.97	mg
Be*	Air	119.00	ng	1,991.94	µg
benzene	Air	6.41	mg	107.30	g
BOD*	Water	3.66	mg	61.26	g
Ca*	Water	4.80	µg	80.35	mg
Cd	Water	174.00	µg	2,912.59	mg
Cd	Air	817.00	ng	13,675.76	µg
chromate*	Water	401.00	ng	6,712.34	µg
Cl-*	Water	174.00	mg	2,912.59	g
Cl2*	Air	1.54	mg	25.78	g
CO*	Air	3.21	g	53.73	kg
CO2	Air	495.00	g	8,285.81	kg
CO2 (fossil)	Air	124.00	g	2,075.64	kg
CO2 (non-fossil)	Air	45.60	mg	763.30	g
coal	Raw	399.00	g	6,678.86	kg
cobalt*	Air	524.00	ng	8,771.24	µg
COD*	Water	39.70	mg	664.54	g
Cr	Water	174.00	µg	2,912.59	mg
Cr	Air	11.40	µg	190.82	mg
crude oil	Raw	13.10	g	219.28	kg
CxHy aromatic	Air	424.00	mg	7,097.34	g
CxHy chloro	Air	17.50	mg	292.93	g
cyanide*	Water	261.00	ng	4,368.88	µg
dichloromethane	Air	13.70	mg	229.32	g
dioxin (TEQ)	Air	0.67	pg	11.22	ng
dissolved solids*	Water	3.82	g	63.94	kg
Douglas-fir logs*	Raw	1.67	kg	27,562.00	kg
energy from hydro power*	Raw	1,130.00	kJ	18,915.07	MJ
energy from oil	Raw	1.66	MJ	27.79	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Fe*	Air	866.00	µg	14,495.97	mg
Fe*	Water	520.00	µg	8,704.28	mg
fluoride ions*	Water	22.20	µg	371.61	mg
formaldehyde	Air	95.80	mg	1,603.60	g
H2SO4*	Water	93.10	µg	1,558.40	mg
HCl*	Air	628.00	µg	10,512.09	mg
HF*	Air	86.30	µg	1,444.58	mg
Hg	Water	13.70	ng	229.32	µg
Hg	Air	387.00	ng	6,477.99	µg
K*	Air	154.00	mg	2,577.81	g
kerosene*	Air	5.58	µg	93.40	mg
limestone*	Raw	23.00	g	385.00	kg
metallic ions*	Water	238.00	µg	3,983.88	mg
metals	Air	18.10	µg	302.98	mg
methane	Air	492.00	mg	8,235.59	g
methanol	Air	104.00	mg	1,740.86	g
methyl bromide	Air	7.91	mg	132.41	g
methyl ethyl ketone	Air	17.50	mg	292.93	g
methyl i-butyl ketone	Air	36.50	mg	610.97	g
Mn*	Water	273.00	µµg	4,569.75	mg
Mn*	Air	1.77	mg	29.63	g
n-nitrodimethylamine*	Air	26.40	ng	441.91	µg
N2O	Air	71.40	µg	1,195.16	mg
Na*	Air	3.54	mg	59.26	g
Na*	Water	8.83	µg	147.81	mg
naphthalene*	Air	472.00	µg	7,900.81	mg
natural gas (feedstock)	Raw	28.40	dm3	475,387.60	dm3
natural gas	Raw	72.70	g	1,216.93	kg
NH3*	Water	64.80	µg	1,084.69	mg
Ni	Air	118.00	µg	1,975.20	mg
nitrate*	Water	2,100.00	ng	35,151.90	µg
non methane VOC	Air	742.00	mg	12,420.34	g
NOx	Air	961.00	mg	16,086.18	g
o-xylene	Air	5.58	mg	93.40	g
oil*	Water	67.50	mg	1,129.88	g
organic substances*	Air	98.20	mg	1,643.77	g
other organics*	Water	11.00	mg	184.13	g
particulates*	Air	2.03	g	33.98	kg
Pb	Water	19.80	ng	331.43	µg
Pb	Air	314.00	µg	5,256.05	mg
phenol*	Water	772.00	ng	12,922.51	µg
phenol*	Air	115.00	mg	1,924.99	g
phosphate*	Water	47.20	µg	790.08	mg
radioactive substance to air*	Non mat.	149.00	Bq	2,494.11	Bq
Sb*	Air	196.00	ng	3,280.84	µg
Se*	Air	1,030.00	ng	17,241.17	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL	Unit:
SO2	Air	66.40	mg	1,111.47	g
solid waste*	Solid	26.90	g	450.28	kg
SOx	Air	2.59	g	43.35	kg
styrene	Air	8.66	mg	144.96	g
sulphate*	Water	139.00	mg	2,326.72	g
suspended solids*	Water	43.40	mg	726.47	g
tetrachloroethene	Air	120.00	ng	2,008.68	µg
tetrachloromethane	Air	261.00	ng	4,368.88	µg
toluene	Air	8.40	mg	140.61	g
trichloroethene	Air	118.00	ng	1,975.20	µg
uranium*	Raw	34.80	µg	582.52	mg
vinyl chloride	Air	5.19	mg	86.88	g
VOC	Air	78.30	mg	1,310.66	g
wood and wood wastes*	Raw	101.00	mg	1,690.64	g
xylene	Air	4.72	mg	79.01	g
Zn	Water	59.90	µg	1,002.67	mg
Zn	Air	866.00	µg	14,495.97	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MCF of LVL in the PNW for the base case using a 100% hog fuel as a heating source.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	14.90	mg	249.41	g
1,2-dichloroethane	Air	8.16	mg	136.59	g
acetaldehyde	Air	31.00	mg	518.91	g
acetone	Air	26.30	mg	440.24	g
Acid as H+*	Water	5.97	ng	99.93	µg
acrolein	Air	15.70	mg	262.80	g
aldehydes	Air	20.20	mg	338.13	g
alkenes	Air	1,488.58	mg	24,917.34	g
ammonia	Air	50.00	µg	836.95	mg
As	Air	24.80	µg	415.13	mg
B*	Water	311.00	µg	5,205.83	mg
Ba*	Air	1,220.00	µg	20,421.58	mg
Be*	Air	35.80	ng	599.26	µg
benzene	Air	7.29	mg	122.03	g
BOD*	Water	1.72	mg	28.79	g
Ca*	Water	4.65	µg	77.84	mg
Cd	Water	85.30	µg	1,427.84	mg
Cd	Air	259.00	ng	4,335.40	µg
chromate*	Water	207.00	ng	3,464.97	µg
Cl-*	Water	85.40	mg	1,429.51	g
Cl2*	Air	2.17	mg	36.32	g
CO*	Air	4.14	g	69.30	kg
CO2	Air	666.00	g	11,148.17	kg
CO2 (fossil)	Air	26.20	g	438.56	kg
CO2 (non-fossil)	Air	24.60	mg	411.78	g
coal	Raw	563.00	g	9,424.06	kg
cobalt*	Air	307.00	ng	5,138.87	µg
COD*	Water	12.20	mg	204.22	g
Cr	Water	85.30	µg	1,427.84	mg
Cr	Air	13.30	µg	222.63	mg
crude oil	Raw	9.49	g	158.85	kg
CxHy aromatic	Air	419.00	mg	7,013.64	g
CxHy chloro	Air	20.80	mg	348.17	g
cyanide*	Water	128.00	ng	2,142.59	µg
Douglas-fir logs*	Raw	1.67	Kg	27,562.00	kg
dichloromethane	Air	13.60	mg	227.65	g
dioxin (TEQ)	Air	0.60	pg	10.08	ng
dissolved solids*	Water	1.86	g	31.13	kg
energy from hydro power*	Raw	1,170.00	kJ	19,584.63	MJ
energy from oil	Raw	1.66	MJ	27.79	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Fe*	Air	1,220.00	µg	20,421.58	mg
Fe*	Water	476.00	µg	7,967.76	mg
fluoride ions*	Water	21.50	µg	359.89	mg
formaldehyde	Air	85.00	mg	1,422.82	g
H2SO4*	Water	77.70	µg	1,300.62	mg
HCl*	Air	567.00	µg	9,491.01	mg
HF*	Air	78.20	µg	1,308.99	mg
Hg	Water	6.70	ng	112.15	µg
Hg	Air	243.00	ng	4,067.58	µg
K*	Air	217.00	mg	3,632.36	g
kerosene*	Air	5.40	µg	90.39	mg
limestone*	Raw	32.40	g	542.34	kg
metallic ions*	Water	127.00	µg	2,125.85	mg
metals	Air	9.80	µg	164.04	mg
methane	Air	249.00	mg	4,168.01	g
methanol	Air	105.00	mg	1,757.60	g
methyl bromide	Air	7.80	mg	130.56	g
methyl ethyl ketone	Air	17.10	mg	286.24	g
methyl i-butyl ketone	Air	35.70	mg	597.58	g
Mn*	Water	248.00	µg	4,151.27	mg
Mn*	Air	2.50	mg	41.85	g
n-nitrodimethylamine*	Air	23.90	ng	400.06	µg
N2O	Air	63.80	µg	1,067.95	mg
Na*	Air	5.00	mg	83.70	g
Na*	Water	8.55	µg	143.12	mg
naphthalene*	Air	667.00	µg	11,164.91	mg
natural gas (feedstock)	Raw	28.40	dm3	475.39	dm3
natural gas	Raw	36.20	g	605.95	kg
NH3*	Water	20.10	µg	336.45	mg
Ni	Air	159.00	µg	2,661.50	mg
nitrate*	Water	2,030.00	ng	33,980.17	µg
non methane VOC	Air	375.00	mg	6,277.13	g
NOx	Air	851.00	mg	14,244.89	g
o-xylene	Air	5.46	mg	91.39	g
oil*	Water	33.10	mg	554.06	g
organic substances*	Air	111.00	mg	1,858.03	g
other organics*	Water	5.41	mg	90.56	g
particulates*	Air	2.14	g	35.82	kg
Pb	Water	10.60	ng	177.43	µg
Pb	Air	334.00	µg	5,590.83	mg
phenol*	Water	413.00	ng	6,913.21	µg
phenol*	Air	122.00	mg	2,042.16	g
phosphate*	Water	39.20	µg	656.17	mg
radioactive substance to air*	Non mat.	130.00	Bq	2,176.07	Bq
Sb*	Air	120.00	ng	2,008.68	µg
Se*	Air	871.00	ng	14,579.67	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
SO2	Air	66.40	mg	1,111.47	g
solid waste*	Solid	30.70	g	513.89	kg
SOx	Air	1.29	g	21.59	kg
styrene	Air	8.53	mg	142.78	g
sulphate*	Water	69.60	mg	1,165.03	g
suspended solids*	Water	8.25	mg	138.10	g
tetrachloroethene	Air	108.00	ng	1,807.81	µg
tetrachloromethane	Air	184.00	ng	3,079.98	µg
toluene	Air	7.55	mg	126.38	g
trichloroethene	Air	107.00	ng	1,791.07	µg
uranium*	Raw	37.90	µg	634.41	mg
vinyl chloride	Air	7.58	mg	126.88	g
VOC	Air	78.30	mg	1,310.66	g
wood and wood wastes*	Raw	109.00	mg	1,824.55	g
xylene	Air	5.77	mg	96.58	g
Zn	Water	29.40	µg	492.13	mg
Zn	Air	1,220.00	µg	20,421.58	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MCF of LVL in the PNW for the base case with 100% natural gas for heating.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	14.90	mg	249.41	g
1,2-dichloroethane	Air	8.16	mg	136.59	g
acetaldehyde	Air	30.10	mg	503.84	g
acetone	Air	26.30	mg	440.24	g
Acid as H+*	Water	7.74	ng	129.56	µg
acrolein	Air	15.70	mg	262.80	g
aldehydes	Air	21.10	mg	353.19	g
alkenes	Air	1,488.58	mg	24,917.34	g
ammonia	Air	76.10	µg	1,273.84	mg
As	Air	-2.37	µg	-39.67	mg
B*	Water	542.00	µg	9,072.54	mg
Ba*	Air	-163.00	µg	-2,728.46	mg
Be*	Air	74.30	ng	1,243.71	mg
benzene	Air	6.16	mg	103.11	g
BOD*	Water	9.92	mg	166.05	g
Ca*	Water	5.78	µg	96.75	mg
Cd	Water	471.00	µg	7,884.07	mg
Cd	Air	1,000.00	ng	16,739.00	µg
chromate*	Water	813.00	ng	13,608.81	µg
Cl-*	Water	471.00	mg	7,884.07	g
Cl2*	Air	-287.00	µg	-4,804.09	mg
CO*	Air	591.00	mg	9,892.75	g
CO2	Air	4.04	g	67.63	kg
CO2 (fossil)	Air	394.00	g	6,595.17	kg
CO2 (non-fossil)	Air	102.00	mg	1,707.38	g
coal	Raw	-69.90	g	-1,170.06	kg
cobalt*	Air	995.00	ng	16,655.31	µg
COD*	Water	131.00	mg	2,192.81	g
Cr	Water	471.00	µg	7,884.07	mg
Cr	Air	-0.61	µg	-10.19	mg
crude oil	Raw	6.92	g	115.83	kg
CxHy aromatic	Air	419.00	mg	7,013.64	g
CxHy chloro	Air	20.80	mg	348.17	g
cyanide*	Water	706.00	ng	11,817.73	µg
Douglas-fir logs*	Raw	1.67	kg	27,562.00	kg
dichloromethane	Air	13.60	mg	227.65	g
dioxin (TEQ)	Air	0.91	pg	15.15	ng
dissolved solids*	Water	10.40	g	174.09	kg
energy from hydro power*	Raw	1,170.00	kJ	19,584.63	MJ
energy from oil	Raw	1.66	MJ	27.79	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Fe*	Air	-163.00	µg	-2,728.46	mg
Fe*	Water	677.00	µg	11,332.30	mg
fluoride ions*	Water	26.70	µg	446.93	mg
formaldehyde	Air	82.90	mg	1,387.66	g
H2SO4*	Water	135.00	µg	2,259.77	mg
HCl*	Air	837.00	µg	14,010.54	mg
HF*	Air	114.00	µg	1,908.25	mg
Hg	Water	37.00	ng	619.34	µg
Hg	Air	447.00	ng	7,482.33	µg
K*	Air	-28.90	mg	-483.76	g
kerosene*	Air	6.72	µg	112.49	mg
limestone*	Raw	-4.03	g	-67.46	g
metallic ions*	Water	165.00	µg	2,761.94	mg
metals	Air	40.10	µg	671.23	mg
methane	Air	1,310.00	mg	21,928.09	g
methanol	Air	105.00	mg	1,757.60	g
methyl bromide	Air	7.80	mg	130.56	g
methyl ethyl ketone	Air	17.10	mg	286.24	g
methyl i-butyl ketone	Air	35.70	mg	597.58	g
Mn*	Water	363.00	µg	6,076.26	mg
Mn*	Air	-331.00	µg	-5,540.61	µg
n-nitrodimethylamine*	Air	35.20	ng	589.21	µg
N2O	Air	96.90	µg	1,622.01	mg
Na*	Air	-666.00	µg	-11,148.17	mg
Na*	Water	10.60	µg	177.43	mg
naphthalene*	Air	-88.70	µg	-1,484.75	mg
natural gas (feedstock)	Raw	28.40	dm3	475,387.60	dm3
natural gas	Raw	195.00	g	3,264.11	g
NH3*	Water	182.00	µg	3,046.50	mg
Ni	Air	-6.54	µg	-109.47	mg
nitrate*	Water	2,520.00	ng	42,182.28	µg
non methane VOC	Air	1,860.00	mg	31,134.54	g
NOx	Air	1,340.00	mg	22,430.26	g
o-xylene	Air	5.46	mg	91.39	g
oil*	Water	182.00	mg	3,046.50	g
organic substances*	Air	61.00	mg	1,021.08	g
other organics*	Water	29.60	mg	495.47	g
particulates*	Air	2.12	g	35.49	kg
Pb	Water	13.60	ng	227.65	µg
Pb	Air	-43.10	µg	-721.45	mg
phenol*	Water	534.00	ng	8,938.63	µg
phenol*	Air	109.00	mg	1,824.55	g
phosphate*	Water	69.40	µg	1,161.69	mg
radioactive substance to air*	Non mat.	211.00	Bq	3,531,929.00	Bq
Sb*	Air	365.00	ng	6,109.74	µg
Se*	Air	1,480.00	ng	24,773.72	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
SO2	Air	66.40	mg	1,111.47	g
solid waste*	Solid	17.40	g	291.26	kg
SOx	Air	6.89	g	115.33	kg
styrene	Air	8.53	mg	142.78	g
sulphate*	Water	372.00	mg	6,226.91	g
suspended solids*	Water	161.00	mg	2,694.98	g
tetrachloroethene	Air	163.00	ng	2,728.46	µg
tetrachloromethane	Air	487.00	ng	8,151.89	µg
toluene	Air	7.55	mg	126.38	g
trichloroethene	Air	156.00	ng	2,611.28	µg
uranium*	Raw	28.80	µg	482.08	mg
vinyl chloride	Air	7.58	mg	126.88	g
VOC	Air	78.30	mg	1,310.66	g
wood and wood wastes*	Raw	71.70	mg	1,200.19	g
xylene	Air	5.77	mg	96.58	g
Zn	Water	162.00	µg	2,711.72	mg
Zn	Air	-163.00	µg	-2,728.46	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of plywood in the Southern region for the base case.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	6.63	mg	127.06	g
1,2-dichloroethane	Air	3.64	mg	69.76	g
acetaldehyde	Air	41.00	mg	785.77	g
acetone	Air	58.00	mg	1,111.57	g
Acid as H+*	Water	10.10	ng	193.57	µg
acrolein	Air	17.20	mg	329.64	g
aldehydes	Air	11.50	mg	220.40	g
alkenes	Air	3,118.61	mg	59,768.16	g
ammonia	Air	251.00	µg	4,810.42	mg
As	Air	15.20	µg	291.31	mg
B*	Water	2,120.00	µg	40,629.80	mg
Ba*	Air	653.00	µg	12,514.75	mg
Be*	Air	254.00	ng	4,867.91	µg
benzene	Air	8.78	mg	168.27	g
BOD*	Water	5.97	mg	114.42	g
Ca*	Water	22.00	µg	421.63	mg
Cd	Water	283.00	µg	5,423.70	mg
Cd	Air	947.00	ng	18,149.26	µg
chromate*	Water	800.00	ng	15,332.00	µg
Cl-*	Water	283.00	mg	5,423.70	g
Cl2*	Air	1,160.00	µg	22,231.40	mg
CO*	Air	2.82	g	54.05	kg
CO2	Air	393.00	g	7,531.85	kg
CO2 (fossil)	Air	265.00	g	5,078.73	kg
CO2 (non-fossil)	Air	83.00	mg	1,590.70	g
coal	Raw	321.00	g	6,151.97	kg
cobalt*	Air	1,390.00	ng	26,639.35	µg
COD*	Water	73.20	mg	1,402.88	g
Cr	Water	283.00	µg	5,423.70	mg
Cr	Air	10.20	µg	195.48	mg
crude oil	Raw	11.60	g	222.31	kg
CxHy aromatic	Air	186.00	mg	3,564.69	g
CxHy chloro	Air	5.90	mg	113.07	g
cyanide*	Water	425.00	ng	8,145.13	µg
dichloromethane	Air	3.11	mg	59.60	g
dioxin (TEQ)	Air	4.38	pg	83.94	ng
dissolved solids*	Water	6.22	g	119.21	g
energy from hydro power*	Raw	46.20	kJ	885.42	MJ
energy from oil	Raw	1.64	MJ	31.43	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Fe*	Air	653.00	µg	12,514.75	mg
Fe*	Water	3.17	mg	60.75	g
fluoride ions*	Water	102.00	µg	1,954.83	mg
formaldehyde	Air	146.00	mg	2,798.09	g
H2SO4*	Water	530.00	µg	10,157.45	mg
HCl*	Air	4.09	mg	78.38	g
HF*	Air	565.00	µg	10,828.23	mg
Hg	Water	22.20	ng	425.46	µg
Hg	Air	1,640.00	ng	31,430.60	µg
K*	Air	116.00	mg	2,223.14	g
kerosene*	Air	25.50	µg	488.71	mg
limestone*	Raw	18.50	g	354.55	kg
metallic ions*	Water	214.00	µg	4,101.31	mg
metals	Air	33.00	µg	632.45	mg
methane	Air	903.00	mg	17,306.00	g
methanol	Air	175.00	mg	3,353.88	g
methyl bromide	Air	3.46	mg	66.31	g
methyl ethyl ketone	Air	9.20	mg	176.32	g
methyl i-butyl ketone	Air	8.26	mg	158.30	g
Mn*	Water	1,770.00	µg	33,922.05	mg
Mn*	Air	1,340.00	µg	25,681.10	mg
n-nitrodimethylamine*	Air	172.00	ng	3,296.38	µg
N2O	Air	458.00	µg	8,777.57	mg
Na*	Air	2.67	mg	51.17	g
Na*	Water	40.40	µg	774.27	mg
naphthalene*	Air	356.00	µg	6,822.74	mg
natural gas (feedstock)	Raw	28.20	dm3	540,453.00	dm3
natural gas	Raw	118.00	g	2,261.47	kg
NH3*	Water	138.00	µg	2,644.77	mg
Ni	Air	97.60	µg	1,870.50	mg
nitrate	Water	9.60	µg	183.98	mg
non methane VOC	Air	1,160.00	mg	22,231.40	g
NOx	Air	1,490.00	mg	28,555.85	g
o-xylene	Air	3.86	mg	73.98	g
oil*	Water	110.00	mg	2,108.15	g
organic substances*	Air	90.40	mg	1,732.52	g
other organics*	Water	18.20	mg	348.80	g
particulates*	Air	1.98	g	37.95	kg
Pb	Water	17.80	ng	341.14	µg
Pb	Air	259.00	µg	4,963.74	mg
phenol*	Water	695.00	ng	13,319.68	µg
phenol*	Air	109.00	mg	2,088.99	g
phosphate*	Water	266.00	µg	5,097.89	mg
radioactive substance to air*	Non mat.	1,060.00	Bq	20,314,900.00	Bq
Sb*	Air	538.00	ng	10,310.77	µg
Se*	Air	5.94	µg	113.84	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
SO2	Air	66.00	mg	1,264.89	g
solid waste*	Solid	35.20	g	674.61	kg
Southern Yellow Pine logs*	Raw	1.45	kg	27,868.00	kg
SOx	Air	4.44	g	85.09	kg
styrene	Air	3.99	mg	76.47	g
sulphate*	Water	235.00	mg	4,503.78	g
suspended solids*	Water	115.00	mg	2,203.98	g
tetrachloroethene	Air	774.00	ng	14,833.71	µg
tetrachloromethane	Air	1,230.00	ng	23,572.95	µg
toluene	Air	9.96	mg	190.88	g
trichloroethene	Air	767.00	ng	14,699.56	µg
uranium*	Raw	123.00	µg	2,357.30	mg
vinyl chloride	Air	2.27	mg	43.50	g
VOC	Air	77.80	mg	1,491.04	g
wood and wood wastes*	Raw	114.00	mg	2,184.81	g
xylene	Air	6.42	mg	123.04	g
Zn	Water	97.30	µg	1,864.75	mg
Zn	Air	653.00	µg	12,514.75	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood in the Southern region for the base case without a RTO.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	8.89	mg	170,376.85	g
1,2-dichloroethane	Air	4.00	mg	76,660.00	g
acetaldehyde	Air	56.90	mg	1,090,488.50	g
acetone	Air	75.60	mg	1,448,874.00	g
Acid as H+*	Water	9.95	ng	190,691.75	µg
acrolein	Air	18.20	mg	348,803.00	g
aldehydes	Air	12.30	mg	235,729.50	g
alkenes	Air	5,658.61	mg	108,447,260.65	g
ammonia	Air	243.00	µg	4,657,095.00	mg
As	Air	14.70	µg	281,725.50	mg
B*	Water	2,050.00	µg	39,288,250.00	mg
Ba*	Air	635.00	µg	12,169,775.00	mg
Be*	Air	246.00	ng	4,714,590.00	mg
benzene	Air	9.46	mg	181,300.90	g
BOD*	Water	5.86	mg	112,306.90	g
Ca*	Water	21.30	µg	408,214.50	mg
Cd	Water	278.00	µg	5,327,870.00	mg
Cd	Air	928.00	ng	17,785,120.00	µg
chromate*	Water	780.00	ng	14,948,700.00	µg
Cl-*	Water	278.00	mg	5,327,870.00	g
Cl2*	Air	1,130.00	µg	21,656,450.00	mg
CO*	Air	2.73	g	52,320.45	kg
CO2	Air	384.00	g	7,359,360.00	kg
CO2 (fossil)	Air	258.00	g	4,944,570.00	kg
CO2 (non-fossil)	Air	81.30	mg	1,558,114.50	g
coal	Raw	312.00	g	5,979,480.00	kg
cobalt*	Air	1,350.00	ng	25,872,750.00	µg
COD*	Water	71.70	mg	1,374,130.50	g
Cr	Water	278.00	µg	5,327,870.00	mg
Cr	Air	9.91	µg	189,925.15	mg
crude oil	Raw	11.40	g	218,481.00	kg
CxHy aromatic	Air	206.00	mg	3,947,990.00	g
CxHy chloro	Air	6.53	mg	125,147.45	g
cyanide*	Water	417.00	ng	7,991,805.00	µg
dichloromethane	Air	3.43	mg	65,735.95	g
dioxin (TEQ)	Air	4.23	pg	81,067.95	ng
dissolved solids*	Water	6.11	g	117,098.15	kg
energy from hydro power*	Raw	44.60	kJ	854,759.00	MJ
energy from oil	Raw	1.64	MJ	31,430.60	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
ethane	Air	1.70	mg	32,580.50	g
Fe*	Air	635.00	µg	12,169,775.00	mg
Fe*	Water	3.06	mg	58,644.90	g
fluoride ions*	Water	98.40	µg	1,885,836.00	mg
formaldehyde	Air	156.00	mg	2,989,740.00	g
H2SO4*	Water	513.00	µg	9,831,645.00	mg
HCl*	Air	3.95	mg	75,701.75	g
HF*	Air	546.00	µg	10,464,090.00	mg
Hg	Water	21.90	ng	419,713.50	µg
Hg	Air	1,580.00	ng	30,280,700.00	µg
K*	Air	113.00	mg	2,165,645.00	g
kerosene*	Air	24.70	µg	473,375.50	mg
limestone*	Raw	18.00	g	344,970.00	kg
metallic ions*	Water	212.00	µg	4,062,980.00	mg
metals	Air	32.30	µg	619,029.50	mg
methane	Air	869.00	mg	16,654,385.00	g
methanol	Air	223.00	mg	4,273,795.00	g
methyl bromide	Air	3.83	mg	73,401.95	g
methyl ethyl ketone	Air	10.00	mg	191,650.00	g
methyl i-butyl ketone	Air	9.14	mg	175,168.10	g
Mn*	Water	1,710.00	µg	32,772,150.00	mg
Mn*	Air	1,310.00	µg	25,106,150.00	mg
n-nitrodimethylamine*	Air	166.00	ng	3,181,390.00	µg
N2O	Air	443.00	µg	8,490,095.00	mg
Na*	Air	2.60	mg	49,829.00	g
Na*	Water	39.10	µg	749,351.50	mg
naphthalene*	Air	347.00	µg	6,650,255.00	mg
natural gas (feedstock)	Raw	28.20	dm3	540,453.00	dm3
natural gas	Raw	116.00	g	2,223,140.00	kg
NH3*	Water	134.00	µg	2,568,110.00	mg
Ni	Air	95.00	µg	1,820,675.00	mg
nitrate*	Water	9.28	µg	177,851.20	mg
non methane VOC	Air	1,140.00	mg	21,848,100.00	g
NOx	Air	1,460.00	mg	27,980,900.00	g
o-xylene	Air	4.29	mg	82,217.85	g
oil*	Water	108.00	mg	2,069,820.00	g
organic substances*	Air	89.70	mg	1,719,100.50	g
other organics*	Water	17.80	mg	341,137.00	g
particulates*	Air	2.87	g	55,003.55	kg
Pb	Water	17.60	ng	337,304.00	µg
Pb	Air	252.00	µg	4,829,580.00	mg
phenol*	Water	687.00	ng	13,166,355.00	µg
phenol*	Air	109.00	mg	2,088,985.00	g
phosphate*	Water	257.00	µg	4,925,405.00	mg
radioactive substance to air*	Non mat.	1,020.00	Bq	19,548,300.00	Bq
Sb*	Air	524.00	ng	10,042,460.00	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Se*	Air	5.74	µg	110,007.10	mg
SO2	Air	66.00	mg	1,264,890.00	g
solid waste*	Solid	34.30	g	657,359.50	kg
Southern Yellow Pine	Raw	1.45	kg	27,868.00	kg
SOx	Air	4.35	g	83,367.75	kg
styrene	Air	4.40	mg	84,326.00	g
sulphate*	Water	230.00	mg	4,407,950.00	g
suspended solids*	Water	112.00	mg	2,146,480.00	g
tetrachloroethene	Air	749.00	ng	14,354,585.00	µg
tetrachloromethane	Air	1,190.00	ng	22,806,350.00	µg
toluene	Air	10.30	mg	197,399.50	g
trichloroethene	Air	742.00	ng	14,220,430.00	µg
uranium*	Raw	119.00	µg	2,280,635.00	mg
vinyl chloride	Air	2.51	mg	48,104.15	g
VOC	Air	77.80	mg	1,491,037.00	g
wood and wood wastes*	Raw	111.00	mg	2,127,315.00	g
xylene	Air	6.84	mg	131,088.60	g
Zn	Water	95.60	µg	1,832,174.00	mg
Zn	Air	635.00	µg	12,169,775.00	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of Plywood in the Southern region for the base case with one direct-natural gas-fired dryer and one indirect steam heated dryer and a RCO.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	7.39	mg	141.63	g
1,2-dichloroethane	Air	3.99	mg	76.47	g
acetaldehyde	Air	86.00	mg	1,648.19	g
acetone	Air	93.50	mg	1,791.93	g
Acid as H+*	Water	9.09	ng	174.21	µg
acrolein	Air	17.80	mg	341.14	g
aldehydes	Air	12.20	mg	233.81	g
alkenes	Air	3,178.61	mg	60,918.06	g
ammonia	Air	242.00	µg	4,637.93	mg
As	Air	11.00	µg	210.82	mg
B*	Water	2,070.00	µg	39,671.55	mg
Ba*	Air	449.00	µg	8,605.09	mg
Be*	Air	239.00	ng	4,580.44	µg
benzene	Air	9.35	mg	179.19	g
BOD*	Water	4.78	mg	91.61	g
Ca*	Water	21.70	µg	415.88	mg
Cd	Water	228.00	µg	4,369.62	mg
Cd	Air	797.00	ng	15,274.51	µg
chromate*	Water	702.00	ng	13,453.83	µg
Cl-*	Water	228.00	mg	4,369.62	g
Cl2*	Air	799.00	µg	15,312.84	mg
CO*	Air	2,030.00	mg	38,904.95	g
CO2	Air	296.00	g	5,672.84	kg
CO2 (fossil)	Air	209.00	g	4,005.49	kg
CO2 (non-fossil)	Air	71.30	mg	1,366.46	g
coal	Raw	228.00	g	4,369.62	kg
cobalt*	Air	1,280.00	ng	24,531.20	µg
COD*	Water	56.20	mg	1,077.07	g
Cr	Water	228.00	µg	4,369.62	mg
Cr	Air	7.79	µg	149.30	mg
crude oil	Raw	10.00	g	191.65	kg
CxHy aromatic	Air	207.00	mg	3,967.16	g
CxHy chloro	Air	6.54	mg	125.34	g
cyanide*	Water	342.00	ng	6,554.43	µg
dichloromethane	Air	3.48	mg	66.69	g
dioxin (TEQ)	Air	4.30	pg	82.41	ng
dissolved solids*	Water	5.00	g	95.83	kg
energy from hydro power*	Raw	45.90	kJ	879.67	MJ
energy from oil	Raw	1.64	MJ	31.43	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
ethane	Air	6.82	mg	130.71	g
Fe*	Air	449.00	µg	8,605.09	mg
Fe*	Water	3.12	mg	59.79	g
fluoride ions*	Water	100.00	µg	1,916.50	mg
formaldehyde	Air	173.00	mg	3,315.55	g
H2SO4*	Water	518.00	µg	9,927.47	mg
HCl*	Air	4.02	mg	77.04	g
HF*	Air	555.00	µg	10,636.58	mg
Hg	Water	17.90	ng	343.05	µg
Hg	Air	1,590.00	ng	30,472.35	µg
K*	Air	79.70	mg	1,527.45	g
kerosene*	Air	25.20	µg	482.96	mg
limestone*	Raw	13.10	g	251.06	kg
metallic ions*	Water	194.00	µg	3,718.01	mg
metals	Air	28.40	µg	544.29	mg
methane	Air	800.00	mg	15,332.00	g
methanol	Air	177.00	mg	3,392.21	g
methyl bromide	Air	3.85	mg	73.79	g
methyl ethyl ketone	Air	10.10	mg	193.57	g
methyl i-butyl ketone	Air	9.10	mg	174.40	g
Mn*	Water	1,740.00	µg	33,347.10	mg
Mn*	Air	925.00	µg	17,727.63	mg
n-nitrodimethylamine*	Air	169.00	ng	3,238.89	µg
N2O	Air	450.00	µg	8,624.25	mg
Na*	Air	1,840.00	µg	35,263.60	mg
Na*	Water	39.80	µg	762.77	mg
naphthalene*	Air	245.00	µg	4,695.43	mg
natural gas (feedstock)	Raw	28.20	dm3	540,453.00	dm3
natural gas	Raw	94.70	g	1,814.93	kg
NH3*	Water	113.00	µg	2,165.65	mg
Ni	Air	70.00	µg	1,341.55	mg
nitrate*	Water	9.46	µg	181.30	mg
non methane VOC	Air	939.00	mg	17,995.94	g
NOx	Air	1,220.00	mg	23,381.30	g
o-xylene	Air	4.27	mg	81.83	g
oil*	Water	88.20	mg	1,690.35	g
organic substances*	Air	82.40	mg	1,579.20	g
other organics*	Water	14.70	mg	281.73	g
particulates*	Air	1.97	g	37.76	kg
Pb	Water	16.10	ng	308.56	µg
Pb	Air	183.00	µg	3,507.20	mg
phenol*	Water	628.00	ng	12,035.62	µg
phenol*	Air	109.00	mg	2,088.99	g
phosphate*	Water	260.00	µg	4,982.90	mg
radioactive substance to air*	Non mat.	1,040.00	Bq	19,931,600.00	Bq
Sb*	Air	498.00	ng	9,544.17	µg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Se*	Air	5.80	µg	111.16	mg
SO2	Air	66.00	mg	1,264.89	g
solid waste*	Solid	28.60	g	548.12	kg
Southern Yellow Pine logs*	Raw	1.45	kg	27,868.00	kg
SOx	Air	3.62	g	69.38	kg
styrene	Air	4.40	mg	84.33	g
sulphate*	Water	191.00	mg	3,660.52	g
suspended solids*	Water	93.30	mg	1,788.09	g
tetrachloroethene	Air	761.00	ng	14,584.57	µg
tetrachloromethane	Air	1,180.00	ng	22,614.70	µg
toluene	Air	10.40	mg	199.32	g
trichloroethene	Air	754.00	ng	14,450.41	µg
uranium*	Raw	119.00	µg	2,280.64	mg
vinyl chloride	Air	2.52	mg	48.30	g
VOC	Air	77.80	mg	1,491.04	g
wood and wood wastes*	Raw	89.70	mg	1,719.10	g
xylene	Air	6.82	mg	130.71	g
Zn	Water	78.30	µg	1,500.62	mg
Zn	Air	449.00	µg	8,605.09	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of plywood in the Southern region for the base case using 100% hog fuel for heating.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	6.63	mg	127.06	g
1,2-dichloroethane	Air	3.64	mg	69.76	g
acetaldehyde	Air	41.40	mg	793.43	g
acetone	Air	58.00	mg	1,111.57	g
Acid as H+*	Water	6.27	ng	120.16	µg
acrolein	Air	17.20	mg	329.64	g
aldehydes	Air	10.90	mg	208.90	g
alkenes	Air	3,118.61	mg	59,768.16	g
ammonia	Air	224.00	µg	4,292.96	mg
As	Air	29.10	µg	557.70	mg
B*	Water	2,000.00	µg	38,330.00	mg
Ba*	Air	1,370.00	µg	26,256.05	mg
Be*	Air	201.00	ng	3,852.17	µg
benzene	Air	9.37	mg	179.58	g
BOD*	Water	1.83	mg	35.07	g
Ca*	Water	21.40	µg	410.13	mg
Cd	Water	90.60	µg	1,736.35	mg
Cd	Air	395.00	ng	7,570.18	µg
chromate*	Water	464.00	ng	8,892.56	µg
Cl-*	Water	90.90	mg	1,742.10	g
Cl2*	Air	2.43	mg	46.57	g
CO*	Air	4.66	g	89.31	kg
CO2	Air	734.00	g	14,067.11	kg
CO2 (fossil)	Air	72.50	g	1,389.46	kg
CO2 (non-fossil)	Air	42.50	mg	814.51	g
coal	Raw	648.00	g	12,418.92	kg
cobalt*	Air	1,010.00	ng	19,356.65	µg
COD*	Water	13.90	mg	266.39	g
Cr	Water	90.60	µg	1,736.35	mg
Cr	Air	16.60	µg	318.14	mg
crude oil	Raw	10.30	g	197.40	kg
CxHy aromatic	Air	186.00	mg	3,564.69	g
CxHy chloro	Air	5.90	mg	113.07	g
cyanide*	Water	136.00	ng	2,606.44	µg
dichloromethane	Air	3.11	mg	59.60	g
dioxin (TEQ)	Air	4.22	pg	80.88	ng
dissolved solids*	Water	1.98	g	37.95	kg
energy from hydro power*	Raw	46.20	kJ	885.42	MJ
energy from oil	Raw	1.64	MJ	31.43	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Fe*	Air	1,370.00	µg	26,256.05	mg
Fe*	Water	3.06	mg	58.64	g
fluoride ions*	Water	99.00	µg	1,897.34	mg
formaldehyde	Air	147.00	mg	2,817.26	g
H2SO4*	Water	499.00	µg	9,563.34	mg
HCl*	Air	3.94	mg	75.51	g
HF*	Air	546.00	µg	10,464.09	mg
Hg	Water	7.12	ng	136.45	µg
Hg	Air	1,490.00	ng	28,555.85	µg
K*	Air	243.00	mg	4,657.10	g
kerosene*	Air	24.80	µg	475.29	mg
limestone*	Raw	37.30	g	714.85	kg
metallic ions*	Water	133.00	µg	2,548.95	mg
metals	Air	17.00	µg	325.81	mg
methane	Air	376.00	mg	7,206.04	g
methanol	Air	175.00	mg	3,353.88	g
methyl bromide	Air	3.46	mg	66.31	g
methyl ethyl ketone	Air	9.20	mg	176.32	g
methyl i-butyl ketone	Air	8.26	mg	158.30	g
Mn*	Water	1,710.00	µg	32,772.15	mg
Mn*	Air	2.81	mg	53.85	g
n-nitrodimethylamine*	Air	166.00	ng	3,181.39	µg
N2O	Air	441.00	µg	8,451.77	mg
Na*	Air	5.60	mg	107.32	g
Na*	Water	39.30	µg	753.18	mg
naphthalene*	Air	747.00	µg	14,316.26	mg
natural gas (feedstock)	Raw	28.20	dm3	540,453.00	dm3
natural gas	Raw	38.50	g	737.85	kg
NH3*	Water	52.00	µg	996.58	mg
Ni	Air	183.00	µg	3,507.20	mg
nitrate	Water	9.34	µg	179.00	mg
non methane VOC	Air	398.00	mg	7,627.67	g
NOx	Air	1,250.00	mg	23,956.25	g
o-xylene	Air	3.86	mg	73.98	g
oil*	Water	35.20	mg	674.61	g
organic substances*	Air	116.00	mg	2,223.14	g
other organics*	Water	6.07	mg	116.33	g
particulates*	Air	1.99	g	38.14	kg
Pb	Water	11.10	ng	212.73	µg
Pb	Air	376.00	µg	7,206.04	mg
phenol*	Water	433.00	ng	8,298.45	µg
phenol*	Air	116.00	mg	2,223.14	g
phosphate*	Water	250.00	µg	4,791.25	mg
radioactive substance to air*	Non mat.	1,020.00	Bq	19,548,300.00	Bq
Sb*	Air	403.00	ng	7,723.50	µg
Se*	Air	5.61	µg	107.52	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
SO2	Air	66.00	mg	1,264.89	g
solid waste*	Solid	42.40	g	812.60	kg
Southern Yelow Pine logs*	Raw	1.45	kg	27,868.00	kg
SOx	Air	1.63	g	31.24	kg
styrene	Air	3.99	mg	76.47	g
sulphate*	Water	83.40	mg	1,598.36	g
suspended solids*	Water	39.10	mg	749.35	g
tetrachloroethene	Air	745.00	ng	14,277.93	µg
tetrachloromethane	Air	1,070.00	ng	20,506.55	µg
toluene	Air	9.96	mg	190.88	g
trichloroethene	Air	741.00	ng	14,201.27	µg
uranium*	Raw	128.00	µg	2,453.12	mg
vinyl chloride	Air	2.27	mg	43.50	g
VOC	Air	77.80	mg	1,491.04	g
wood and wood wastes*	Raw	133.00	mg	2,548.95	g
xylene	Air	6.42	mg	123.04	g
Zn	Water	31.20	µg	597.95	mg
Zn	Air	1,370.00	µg	26,256.05	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance List: Shows the basic raw materials and emissions (air, water, soil, solid, non-material) associated with manufacturing MSF of plywood in the Southern region for the base case using 100% natural gas for heating.

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
1,2,4-trichlorobenzene	Air	6.63	mg	127.06	g
1,2-dichloroethane	Air	3.64	mg	69.76	g
acetaldehyde	Air	40.50	mg	776.18	g
acetone	Air	58.00	mg	1,111.57	g
Acid as H+*	Water	8.08	ng	154.85	µg
acrolein	Air	17.20	mg	329.64	g
aldehydes	Air	11.90	mg	228.06	g
alkenes	Air	3,118.61	mg	59,768.16	g
ammonia	Air	251.00	µg	4,810.42	mg
As	Air	1.09	µg	20.89	mg
B*	Water	2,230.00	µg	42,737.95	mg
Ba*	Air	-60.50	µg	-1,159.48	mg
Be*	Air	241.00	ng	4,618.77	µg
benzene	Air	8.20	mg	157.15	g
BOD*	Water	10.30	mg	197.40	g
Ca*	Water	22.60	µg	433.13	mg
Cd	Water	488.00	µg	9,352.52	mg
Cd	Air	1,160.00	ng	22,231.40	µg
chromate*	Water	1,090.00	ng	20,889.85	µg
Cl-*	Water	488.00	mg	9,352.52	g
Cl2*	Air	-105.00	µg	-2,012.33	mg
CO*	Air	1,000.00	mg	19,165.00	g
CO2	Air	52.40	g	1,004.25	kg
CO2 (fossil)	Air	452.00	g	8,662.58	kg
CO2 (non-fossil)	Air	122.00	mg	2,338.13	g
coal	Raw	-4.33	g	-82.98	kg
cobalt*	Air	1,720.00	ng	32,963.80	µg
COD*	Water	136.00	mg	2,606.44	g
Cr	Water	488.00	µg	9,352.52	mg
Cr	Air	2.31	µg	44.27	mg
crude oil	Raw	7.67	g	147.00	kg
CxHy aromatic	Air	186.00	mg	3,564.69	g
CxHy chloro	Air	5.90	mg	113.07	g
cyanide*	Water	732.00	ng	14,028.78	µg
dichloromethane	Air	3.11	mg	59.60	g
dioxin (TEQ)	Air	4.53	pg	86.82	ng
dissolved solids*	Water	10.70	g	205.07	kg
energy from hydro power*	Raw	46.20	kJ	885.42	MJ
energy from oil	Raw	1.64	MJ	31.43	GJ

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
Fe*	Air	-60.50	µg	-1,159.48	mg
Fe*	Water	3.27	mg	62.67	g
fluoride ions*	Water	104.00	µg	1,993.16	mg
formaldehyde	Air	145.00	mg	2,778.93	g
H2SO4*	Water	559.00	µg	10,713.24	mg
HCl*	Air	4.22	mg	80.88	g
HF*	Air	582.00	µg	11,154.03	mg
Hg	Water	38.30	ng	734.02	µg
Hg	Air	1,700.00	ng	32,580.50	µg
K*	Air	-10.70	mg	-205.07	g
kerosene*	Air	26.20	µg	502.12	mg
limestone*	Raw	-0.25	g	-4.79	kg
metallic ions*	Water	173.00	µg	3,315.55	mg
metals	Air	48.20	µg	923.75	mg
methane	Air	1,460.00	mg	27,980.90	g
methanol	Air	175.00	mg	3,353.88	g
methyl bromide	Air	3.46	mg	66.31	g
methyl ethyl ketone	Air	9.20	mg	176.32	g
methyl i-butyl ketone	Air	8.26	mg	158.30	g
Mn*	Water	1,830.00	µg	35,071.95	mg
Mn*	Air	-117.00	µg	-2,242.31	mg
n-nitrodimethylamine*	Air	177.00	ng	3,392.21	µg
N2O	Air	475.00	µg	9,103.38	mg
Na*	Air	-248.00	µg	-4,752.92	mg
Na*	Water	41.50	µg	795.35	mg
naphthalene*	Air	-32.80	µg	-628.61	mg
natural gas (feedstock)	Raw	28.20	dm3	540,453.00	dm3
natural gas	Raw	202.00	g	3,871.33	kg
NH3*	Water	219.00	µg	4,197.14	mg
Ni	Air	11.60	µg	222.31	mg
nitrate	Water	9.85	µg	188.78	mg
non methane VOC	Air	1,930.00	mg	36,988.45	g
NOx	Air	1,750.00	mg	33,538.75	g
o-xylene	Air	3.86	mg	73.98	g
oil*	Water	188.00	mg	3,603.02	g
organic substances*	Air	64.70	mg	1,239.98	g
other organics*	Water	31.00	mg	594.12	g
particulates*	Air	1.97	g	37.76	kg
Pb	Water	14.20	ng	272.14	µg
Pb	Air	-13.20	µg	-252.98	mg
phenol*	Water	558.00	ng	10,694.07	µg
phenol*	Air	103.00	mg	1,974.00	g
phosphate*	Water	281.00	µg	5,385.37	mg
radioactive substance to air*	Non mat.	1,100.00	Bq	21,081,500.00	Bq
Sb*	Air	656.00	ng	12,572.24	µg
Se*	Air	6.23	µg	119.40	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	per kg of LVL:	Unit:	per MCF of LVL:	Unit:
SO2	Air	66.00	mg	1,264.89	g
solid waste*	Solid	28.60	g	548.12	kg
Southern Yellow Pine logs*	Raw	1.45	kg	27,868.00	kg
SOx	Air	7.41	g	142.01	kg
styrene	Air	3.99	mg	76.47	g
sulphate*	Water	396.00	mg	7,589.34	g
suspended solids*	Water	196.00	mg	3,756.34	g
tetrachloroethene	Air	802.00	ng	15,370.33	µg
tetrachloromethane	Air	1,380.00	ng	26,447.70	µg
toluene	Air	9.96	mg	190.88	g
trichloroethene	Air	792.00	ng	15,178.68	µg
uranium*	Raw	118.00	µg	2,261.47	mg
vinyl chloride	Air	2.27	mg	43.50	g
VOC	Air	77.80	mg	1,491.04	g
wood and wood wastes*	Raw	94.00	mg	1,801.51	g
xylene	Air	6.42	mg	123.04	g
Zn	Water	167.00	µg	3,200.56	mg
Zn	Air	-60.50	µg	-1,159.48	mg

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance list for generating 1 MJ of energy for electricity with coal, Distillate Fuel Oil (DFO), natural gas, and uranium (nuclear power).

Substance:	Category:	Unit:	Coal:	DFO:	Natural Gas:	Uranium:
Acid as H+*	Water	ng	1.32E-01	2.60E+01	2.70E-01	4.36E-02
acrolein	Air	µg	1.50E+00	1.45E-02	8.00E-03	3.88E-02
aldehydes	Air	mg	1.52E-01	1.50E+00	1.47E-01	8.24E-03
ammonia	Air	mg	4.59E-03	1.24E-01	1.27E+00	1.34E-02
As	Air	µg	3.00E+00	1.63E+01	1.31E-01	9.16E-02
B*	Water	mg	3.68E+00	3.80E+00	3.54E-02	1.00E-01
Be*	Air	µg	3.60E-01	1.04E+00	5.90E-03	1.00E-02
benzene	Air	µg	1.15E+00	7.57E-01	5.76E-01	1.31E-01
BOD*	Water	mg	4.96E-03	4.02E-01	1.26E+00	1.22E-02
Ca*	Water	µg	1.78E-01	2.78E-01	1.73E-01	8.37E+01
Cd	Water	µg	1.49E-01	4.02E+00	5.90E+01	5.45E-01
Cd	Air	µg	2.40E-01	2.79E+01	1.30E-01	2.40E-02
chromate*	Water	µg	1.07E-01	2.26E+01	9.27E-02	3.44E-02
Cl-*	Water	mg	4.42E-01	3.99E+00	5.90E+01	9.72E-01
Cl2*	Air	µg	7.02E-02	4.64E+00	9.27E-02	2.18E-01
CO*	Air	mg	1.98E+01	3.36E+01	1.12E+02	2.49E+00
CO2 (fossil)	Air	g	8.93E+01	9.00E+01	5.76E+01	2.97E+00
CO2 (non-fossil)	Air	mg	1.24E+01	1.89E+01	1.18E+01	5.63E+01
coal	Raw	lb	9.16E-02	8.86E-04	5.01E-04	2.40E-03
cobalt*	Air	µg	1.24E+00	2.41E+01	1.47E-01	5.67E-02
COD*	Water	mg	5.37E-02	2.69E+00	1.81E+01	1.68E-01
Cr	Water	µg	1.49E-01	4.02E+00	5.90E+01	5.45E-01
Cr	Air	µg	3.90E+00	1.82E+01	4.59E-01	1.18E-01
crude oil	Raw	g	2.95E-01	2.36E+01	2.95E-01	4.53E-02
cyanide*	Water	ng	2.19E-01	5.87E+00	8.85E+01	7.85E-01
dichloromethane	Air	µg	5.83E+00	1.67E+00	3.71E-02	1.61E-01
dioxin (TEQ)	Air	pg	7.90E+00	7.73E-02	4.63E-02	2.09E-01
dissolved solids*	Water	g	3.39E-03	1.08E-01	1.30E+00	1.18E-02
Fe*	Water	mg	4.96E+00	5.87E-02	3.08E-02	1.94E+00
fluoride ions*	Water	µg	8.26E-01	1.27E+00	8.00E-01	3.88E+02
formaldehyde	Air	mg	1.90E-03	6.49E-05	1.69E-02	1.79E-04
H2SO4*	Water	µg	9.19E+02	9.49E+02	8.85E+00	2.51E+01
HCl*	Air	mg	7.48E+00	7.73E-02	4.13E-02	1.95E-01
HF*	Air	mg	1.04E+00	1.02E-02	5.48E-03	2.69E-02
Hg	Water	ng	1.16E-02	3.03E-01	4.63E+00	4.19E-02
Hg	Air	µg	2.76E+00	4.10E+00	3.17E-02	7.41E-02
kerosene*	Air	µg	2.07E-01	3.09E-01	2.02E-01	9.72E+01
limestone*	Raw	g	2.40E+00	2.33E-02	1.31E-02	6.32E-02
metallic ions*	Water	µg	2.85E+00	5.56E+02	5.90E+00	9.20E-01
metals	Air	µg	4.96E+00	7.73E+00	4.63E+00	2.30E+01
methane	Air	g	1.95E-01	1.34E-02	1.60E-01	6.54E-03

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	Unit:	Coal:	DFO:	Natural Gas:	Uranium:
Mn*	Water	mg	3.22E+00	2.84E-02	1.77E-02	1.72E-01
Mn*	Air	µg	9.73E+00	1.21E+01	2.65E-01	5.06E-01
n-nitrodimethylamine*	Air	ng	3.16E+02	3.06E+00	1.73E+00	8.29E+00
N2O	Air	µg	8.33E+02	3.49E+02	5.05E+00	2.20E+01
Na*	Water	µg	3.31E-01	4.95E-01	3.20E-01	1.54E+02
naphthalene*	Air	µg	1.40E-02	2.16E-02	2.11E-01	6.54E-02
natural gas	Raw	g	6.53E-02	1.64E+00	2.44E+01	2.24E-01
NH3*	Water	µg	5.78E-01	4.33E+01	2.48E+01	1.46E+02
Ni	Air	µg	4.46E+00	3.76E+02	1.67E+00	6.02E-01
nitrate*	Water	µg	7.85E-02	1.21E-01	7.58E-02	3.65E+01
non methane VOC	Air	mg	4.96E+00	1.58E+02	2.24E+02	2.83E+00
NOx	Air	g	3.36E-01	1.87E-01	2.15E-01	2.53E-02
oil*	Water	mg	6.20E-02	2.50E+00	2.27E+01	2.11E-01
organic substances*	Air	mg	2.60E-01	9.27E-01	3.66E-01	2.00E-02
other organics*	Water	mg	7.20E-01	1.00E+00	3.71E+00	5.32E-02
particulates*	Air	g	1.19E-01	1.38E-02	1.88E-03	1.92E-02
Pb	Water	ng	2.35E-01	4.64E+01	4.63E-01	7.85E-02
Pb	Air	µg	3.95E+00	1.56E+01	2.53E-01	1.57E-01
phenol*	Water	µg	9.09E-03	1.79E+00	1.85E-02	2.97E-03
phenol*	Air	mg	3.01E-03	3.71E-04	2.36E-04	1.12E-03
phosphate*	Water	µg	4.59E+02	4.74E+02	4.63E+00	1.25E+01
radioactive substance to air*	Non mat.	Bq	1.20E+03	2.19E+01	2.11E+03	5.87E+01
Sb*	Air	µg	6.20E-01	8.46E+00	3.75E-02	2.14E-02
Se*	Air	µg	1.04E+01	9.50E+00	4.84E-01	2.79E-01
solid waste*	Solid	g	1.75E+01	5.13E-01	2.44E+00	2.94E+00
SOx	Air	mg	5.67E+02	6.39E+02	8.30E+02	7.59E+01
sulphate*	Water	mg	2.19E-01	3.18E+00	4.63E+01	4.88E+01
suspended solids*	Water	g	6.36E-02	8.01E-03	2.33E-02	1.86E-03
tetrachloroethene	Air	µg	1.41E+00	2.89E-01	8.42E-03	3.71E-02
tetrachloromethane	Air	µg	1.58E+00	1.95E+01	4.63E-02	6.54E-02
trichloroethene	Air	µg	1.41E+00	1.36E-02	7.58E-03	3.66E-02
uranium*	Raw	µg	9.92E-01	1.64E+00	9.27E-01	4.40E+02
wood and wood wastes*	Raw	mg	6.61E+00	1.69E+01	9.69E+00	4.52E+01
Zn	Water	µg	5.37E-02	2.01E+00	2.02E+01	1.88E-01

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance list for generating 1 MJ of energy from Distillate Fuel Oil (DFO), Liquid Propane Gas (LPG), Wood, and Natural Gas

Substance:	Category:	Unit:	Wood:	DFO:	LPG:	Natural Gas:
acetaldehyde	Air	µg	1.43E+02	x	x	x
Acid as H+*	Water	ng	x	2.60E+01	2.34E+01	2.67E-01
acrolein	Air	µg	x	1.45E-02	1.30E-02	7.93E-03
aldehydes	Air	mg	x	1.45E+00	1.30E+00	1.46E-01
ammonia	Air	mg	x	1.24E-01	1.12E-01	3.96E-03
As	Air	µg	4.20E+00	1.17E+00	2.20E-01	7.93E-02
B*	Water	mg	x	8.66E-02	7.65E-02	3.50E-02
Ba*	Air	µg	2.10E+02	x	x	x
Be*	Air	µg	x	5.73E-01	1.53E-02	5.84E-03
benzene	Air	µg	1.72E+02	4.64E-02	4.23E-02	2.84E-02
BOD*	Water	mg	x	4.02E-01	3.64E-01	1.24E+00
Ca*	Water	µg	x	2.78E-01	2.52E-01	1.71E-01
Cd	Water	µg	x	4.02E+00	3.60E+00	5.84E+01
Cd	Air	µg	x	2.84E+00	3.33E-01	1.13E-01
chromate*	Water	µg	x	3.03E-01	2.74E-01	9.18E-02
Cl-*	Water	mg	x	3.96E+00	3.60E+00	5.84E+01
Cl2*	Air	µg	3.72E+02	4.64E+00	4.32E+00	9.18E-02
CO*	Air	mg	6.59E+02	3.51E+01	3.33E+01	1.21E+02
CO2	Air	g	1.00E+02	x	x	x
CO2 (fossil)	Air	g	x	7.74E+01	6.86E+01	5.58E+01
CO2 (non-fossil)	Air	mg	x	1.89E+01	1.71E+01	1.17E+01
coal FAL	Raw	lb	2.12E-01	8.86E-04	8.03E-04	4.97E-04
cobalt*	Air	µg	x	3.40E-01	3.01E-01	1.04E-01
COD*	Water	mg	x	2.69E+00	2.47E+00	1.79E+01
Cr	Water	µg	x	4.02E+00	3.69E+00	5.84E+01
Cr	Air	µg	2.20E+00	1.33E+01	2.52E-01	9.59E-02
crude oil FAL	Raw	g	6.81E-01	2.36E+01	2.15E+01	2.92E-01
cyanide*	Water	ng	x	5.87E+00	5.40E+00	8.76E+01
dichloromethane	Air	µg	x	6.49E-02	5.85E-02	3.67E-02
dioxin (TEQ)	Air	pg	x	7.73E-02	7.20E-02	4.59E-02
dissolved solids*	Water	g	x	1.08E-01	9.81E-02	1.29E+00
Fe*	Air	µg	2.10E+02	x	x	x
Fe*	Water	mg	x	5.87E-02	5.40E-02	3.05E-02
fluoride ions*	Water	µg	x	1.27E+00	1.17E+00	7.93E-01
formaldehyde	Air	mg	3.15E-01	6.49E-05	5.85E-05	3.67E-05
H2SO4*	Water	µg	x	2.13E+01	1.93E+01	8.76E+00
HCl*	Air	mg	x	7.73E-02	6.75E-02	4.09E-02
HF*	Air	mg	x	1.02E-02	9.00E-03	5.42E-03
Hg	Water	ng	x	3.03E-01	2.74E-01	4.59E+00
Hg	Air	µg	x	7.60E-01	7.20E-02	3.09E-02
K*	Air	mg	3.72E+01	x	x	x
kerosene*	Air	µg	x	3.09E-01	2.92E-01	2.00E-01

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment

Substance:	Category:	Unit:	Wood:	DFO:	LPG:	Natural Gas:
limestone*	Raw	g	5.54E+00	2.33E-02	2.11E-02	1.29E-02
metallic ions*	Water	µg	x	5.56E+02	4.95E+02	5.84E+00
metals	Air	µg	x	7.73E+00	7.20E+00	4.59E+00
methane	Air	g	x	1.27E-02	1.12E-02	1.60E-01
Mn*	Water	mg	x	2.84E-02	2.56E-02	1.75E-02
Mn*	Air	µg	4.30E+02	3.43E+00	3.01E-01	1.50E-01
n-nitrodimethylamine*	Air	ng	x	3.06E+00	2.79E+00	1.71E+00
N2O	Air	µg	x	8.66E+00	8.10E+00	5.01E+00
Na*	Air	µg	8.59E+02	x	x	x
Na*	Water	µg	x	4.95E-01	4.50E-01	3.17E-01
naphthalene*	Air	µg	1.15E+02	2.16E-02	1.98E-02	1.33E-02
natural gas	Raw	g	1.51E-01	1.64E+00	1.49E+00	2.42E+01
NH3*	Water	µg	x	4.33E+01	3.96E+01	2.46E+01
Ni	Air	µg	2.67E+01	9.27E+00	4.50E+00	1.59E+00
nitrate*	Water	µg	x	1.21E-01	1.08E-01	7.51E-02
non methane VOC	Air	mg	x	1.56E+02	1.41E+02	2.25E+02
NOx	Air	g	1.06E-01	1.00E-01	1.14E-01	1.79E-01
oil*	Water	mg	x	2.50E+00	2.29E+00	2.25E+01
organic substances*	Air	mg	7.92E+00	9.27E-01	8.55E-01	3.63E-01
other organics*	Water	mg	x	2.63E-01	2.38E-01	3.67E+00
particulates*	Air	g	8.40E-03	9.77E-03	7.20E-03	5.51E-03
Pb	Water	ng	x	4.64E+01	4.18E+01	4.59E-01
Pb	Air	mg	5.73E-02	2.41E-03	1.26E+00	1.17E-04
phenol*	Water	µg	x	1.79E+00	1.62E+00	1.84E-02
phenol*	Air	mg	1.91E+00	3.71E-04	3.46E-04	2.34E-04
phosphate*	Water	µg	x	1.08E+01	9.90E+00	4.59E+00
radioactive substance to air*	Non mat.	Bq	x	2.19E+01	1.98E+01	1.22E+01
Sb*	Air	µg	x	1.17E-01	1.08E-01	3.71E-02
Se*	Air	µg	x	2.23E-01	2.02E-01	9.18E-02
solid waste*	Solid	g	4.44E+00	4.11E-01	3.73E-01	2.42E+00
SOx	Air	mg	4.77E+00	1.69E+02	7.25E+01	8.53E+02
sulphate*	Water	mg	x	3.18E+00	2.92E+00	4.59E+01
suspended solids*	Water	g	x	2.44E-03	2.25E-03	2.31E-02
tetrachloroethene	Air	µg	x	1.42E-02	1.30E-02	8.34E-03
tetrachloromethane	Air	µg	x	5.87E-02	5.40E-02	4.59E-02
trichloroethene	Air	µg	x	1.36E-02	1.26E-02	7.51E-03
uranium*	Raw	µg	2.29E+00	1.64E+00	1.48E+00	9.18E-01
wood and wood wastes*	Raw	mg	1.53E+01	1.69E+01	1.53E+01	9.59E+00
Zn	Water	µg	x	2.01E+00	1.84E+00	2.00E+01
Zn	Air	µg	2.10E+02	x	x	x

* Denotes substance not defined by the Eco-Indicator99 Methodology, thus not included in impact assessment